

Mercury Cycling in Aquatic Ecosystems: Things that Matter other than Loading

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**Presentation to the Utah Statewide Mercury
Workgroup
November 18, 2008**



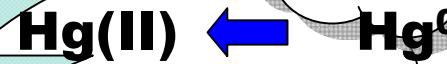
Presentation Outline:

- How important are variations in Hg loading (time and space)?
 - METAALICUS project
 - ACME (Everglades) project
 - Midwest Lakes survey
- Reservoirs – what can be done?
- Discussion

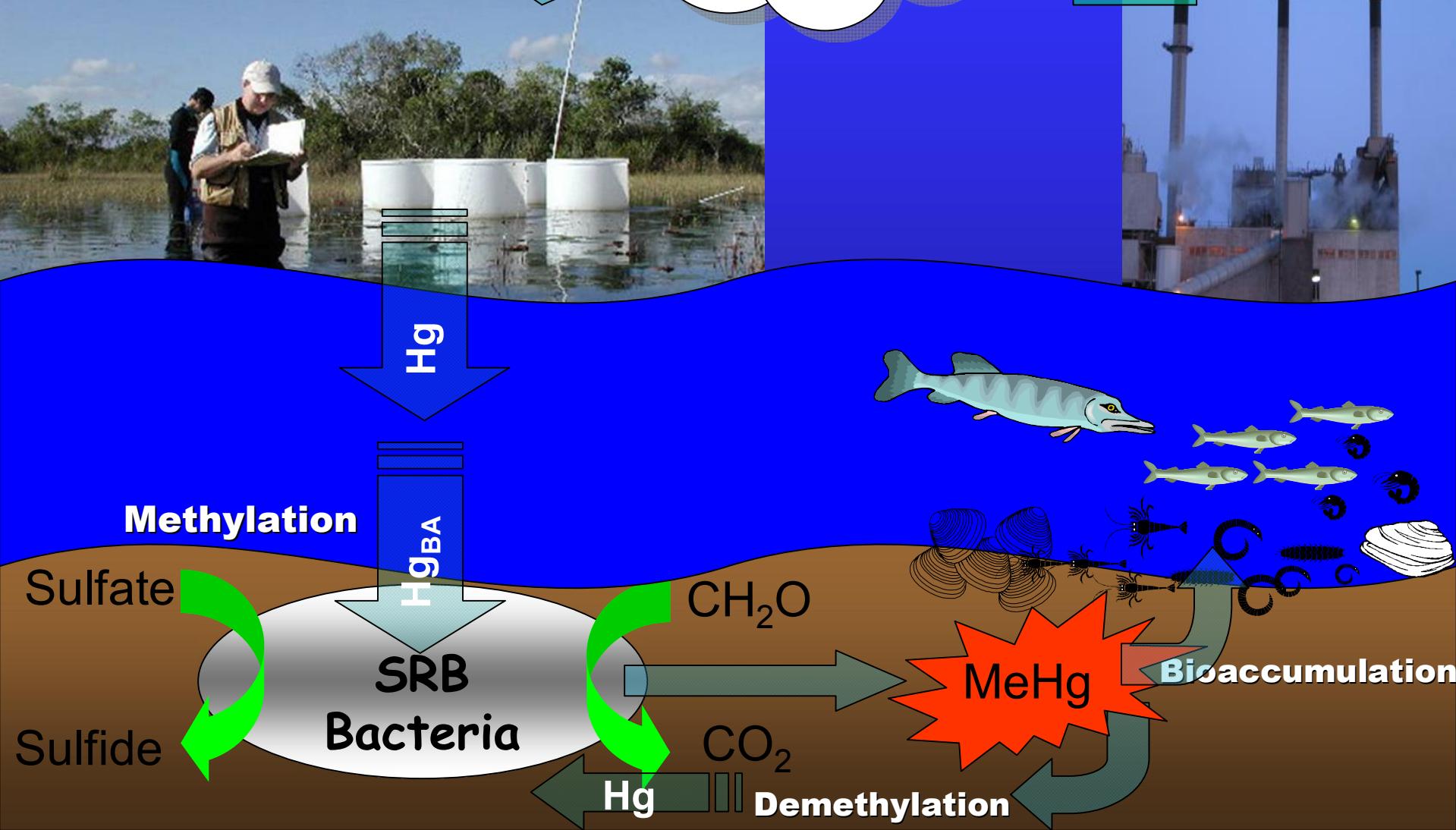
Yellowstone NP, USA

The Mercury Cycle

Deposition



Emissions



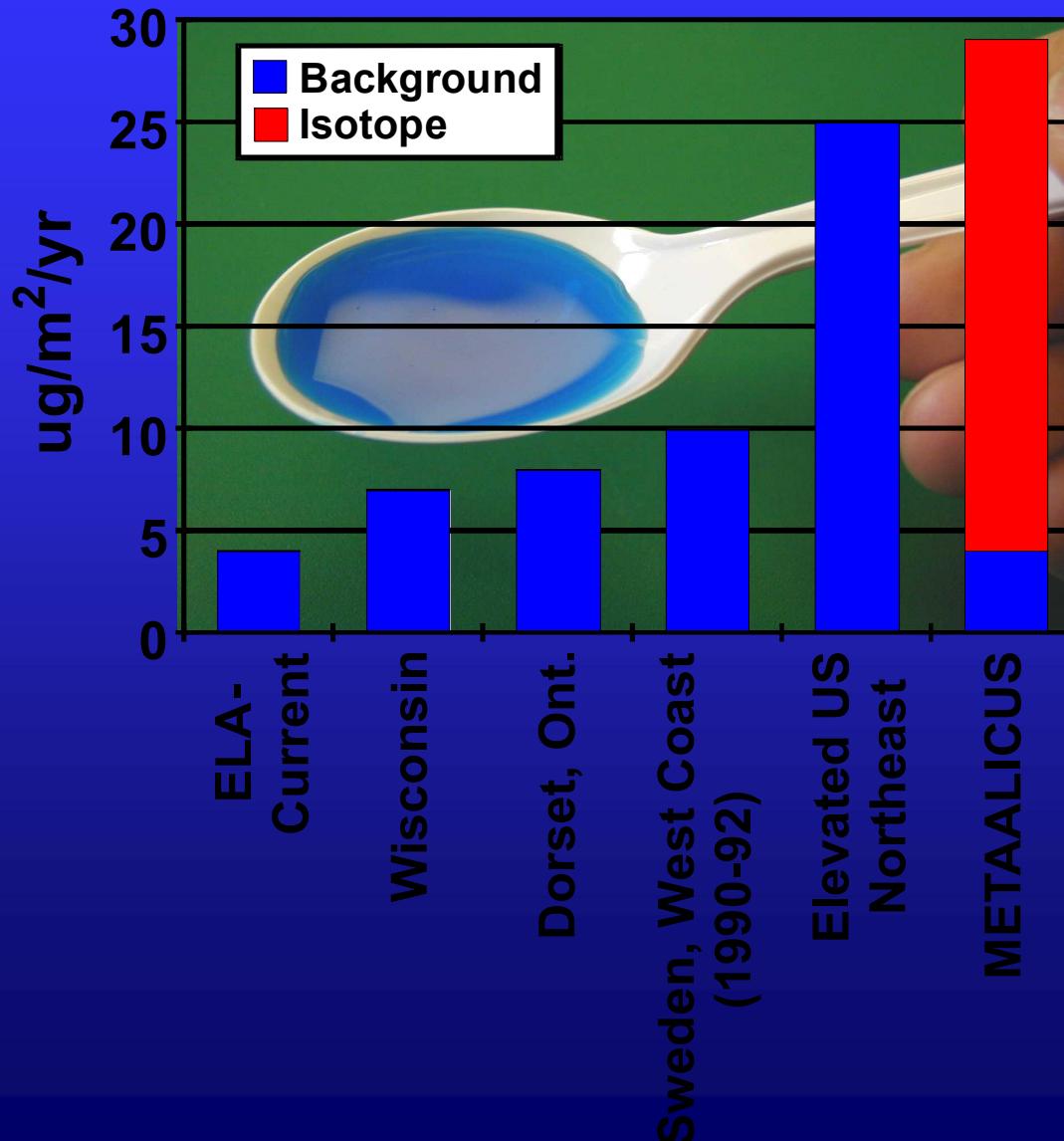
How important
are mercury load
reductions, if the
whole planet is
already
contaminated?



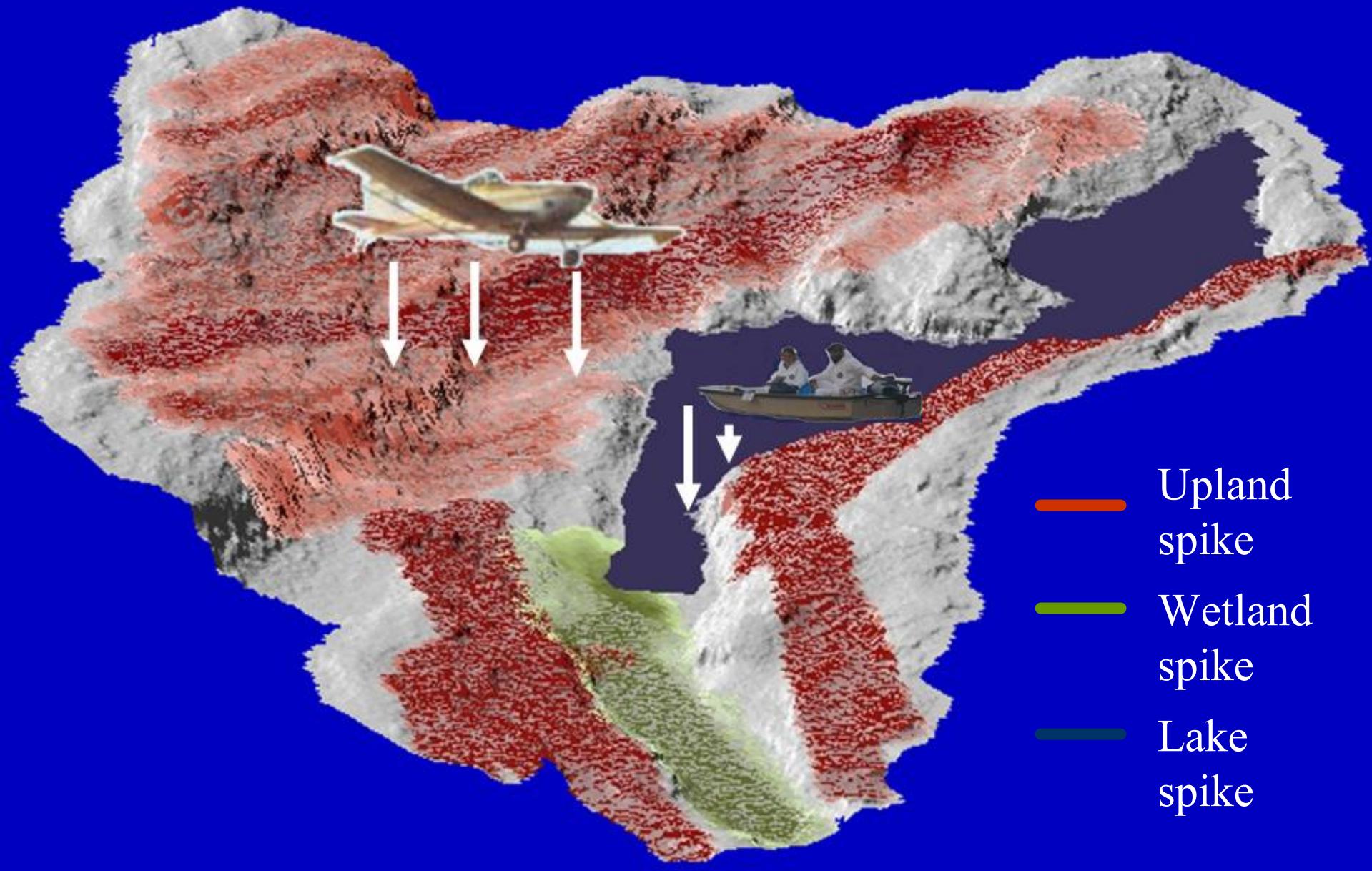


Mercury Experiment to Assess
Atmospheric
Loadings In Canada and the
United States

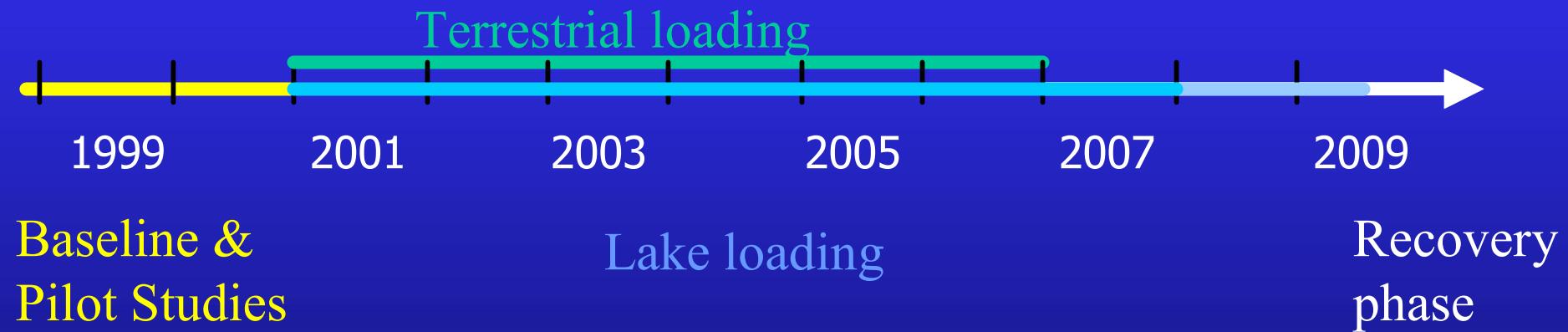
How much mercury are we adding?



Hg is applied each year by plane and boat..

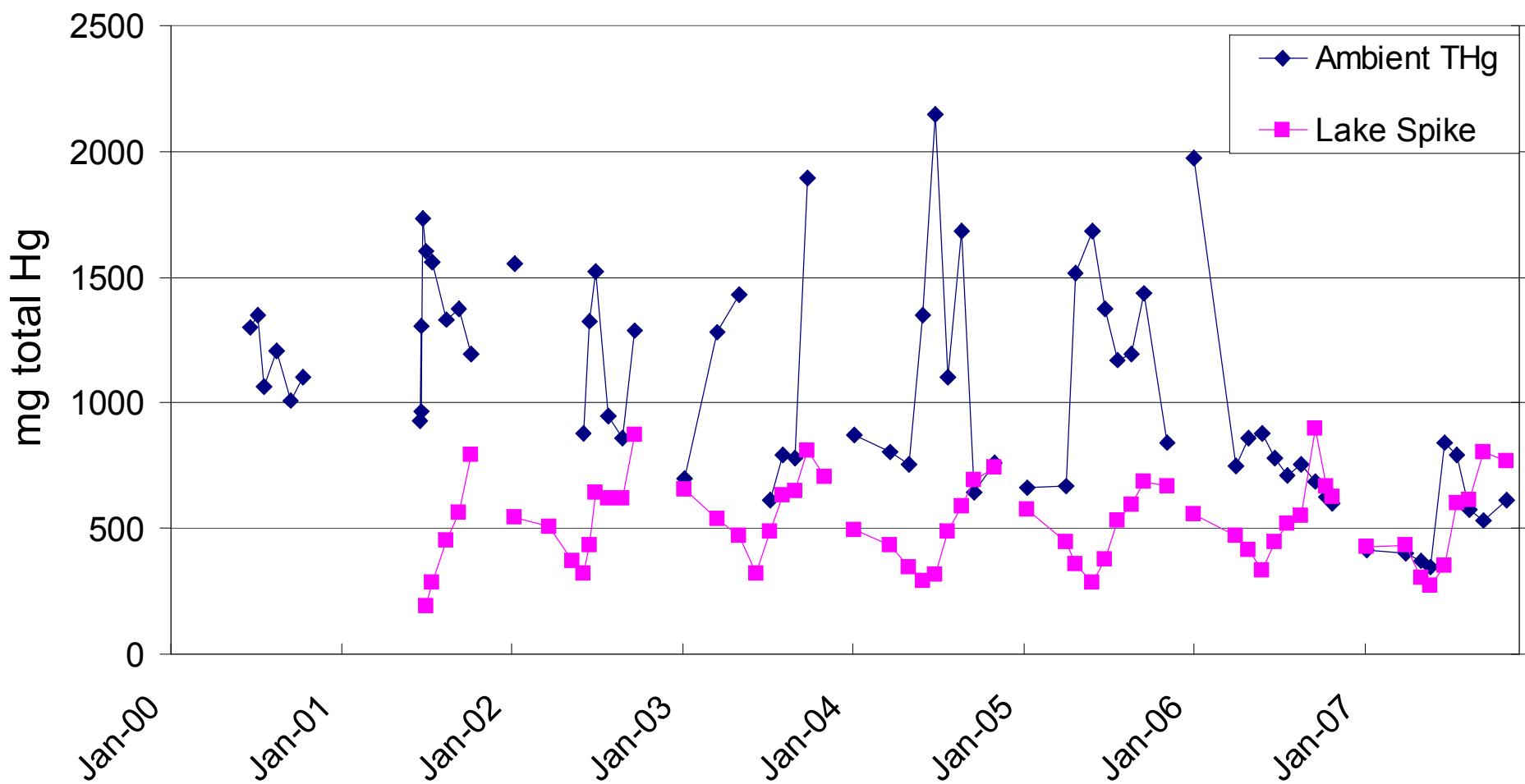


METAALICUS Schedule

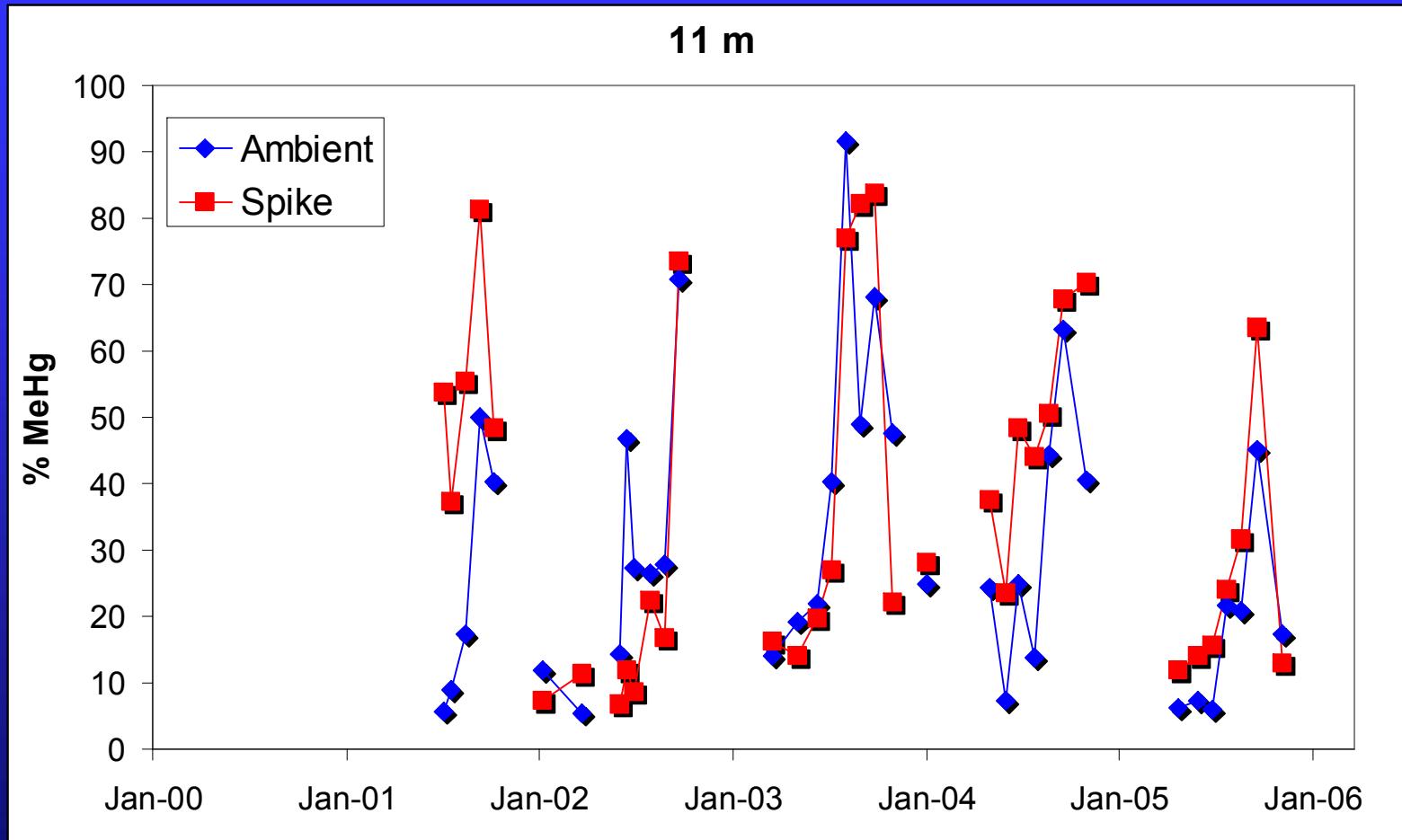


How did the lake respond?

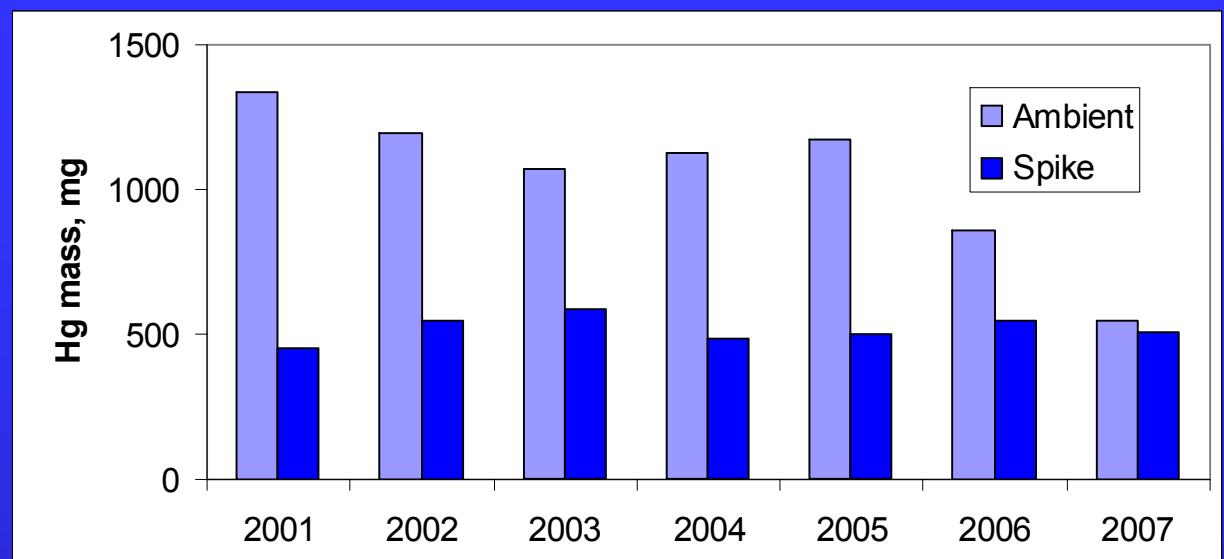
Total Hg mass, water column



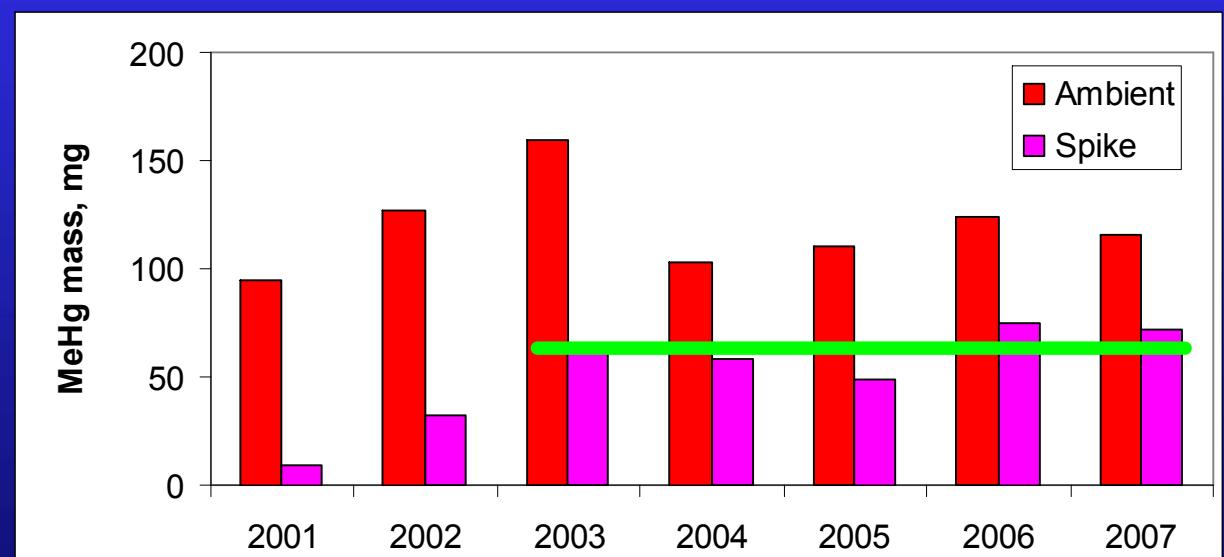
Spike and Ambient Hg are methylated equally in the water column



Annual average mass of Hg in L658 water column



Annual average mass of MeHg in L658 water column



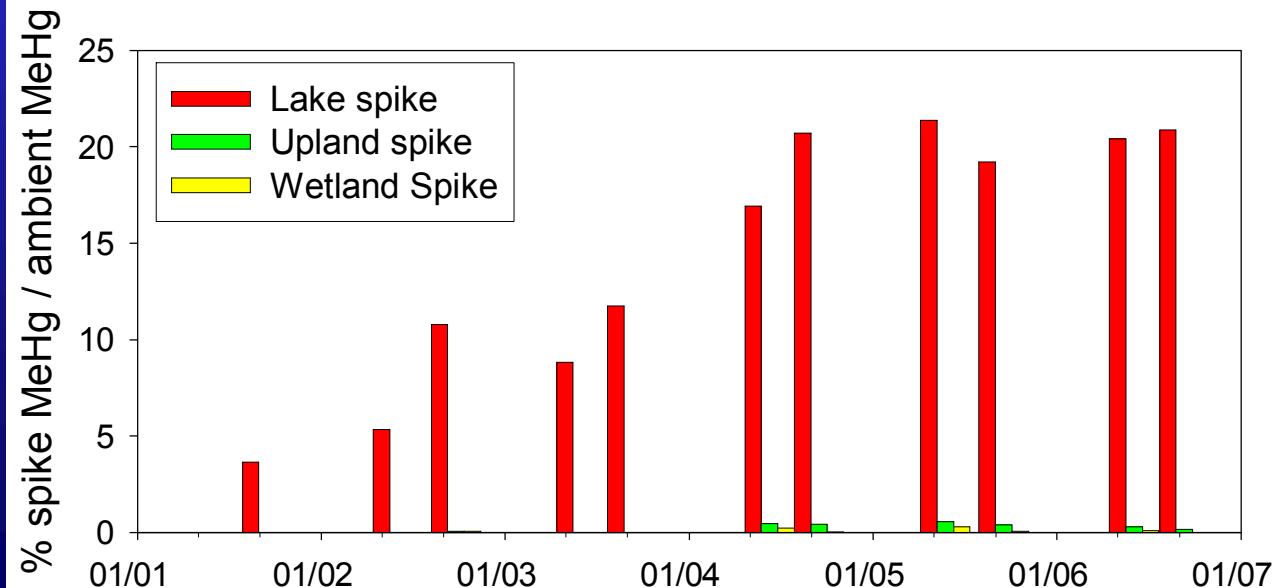
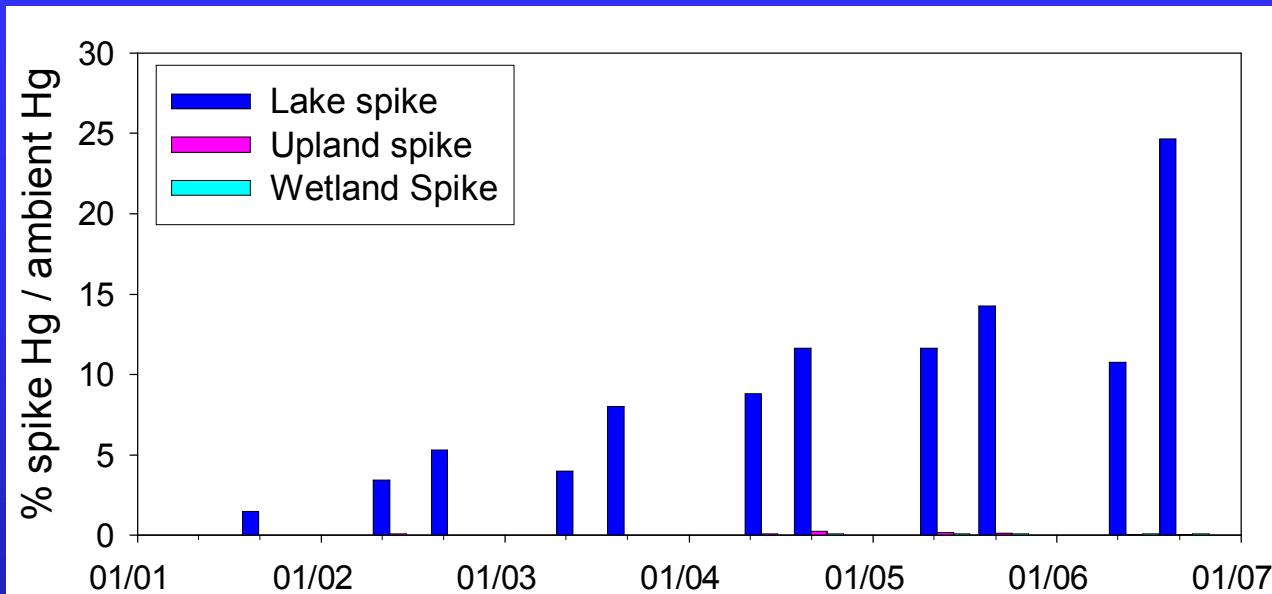
Equilibrium after 3 years?

How did sediments respond?

Increase in sediment Hg due to spike



Increase in sediment MeHg due to spike



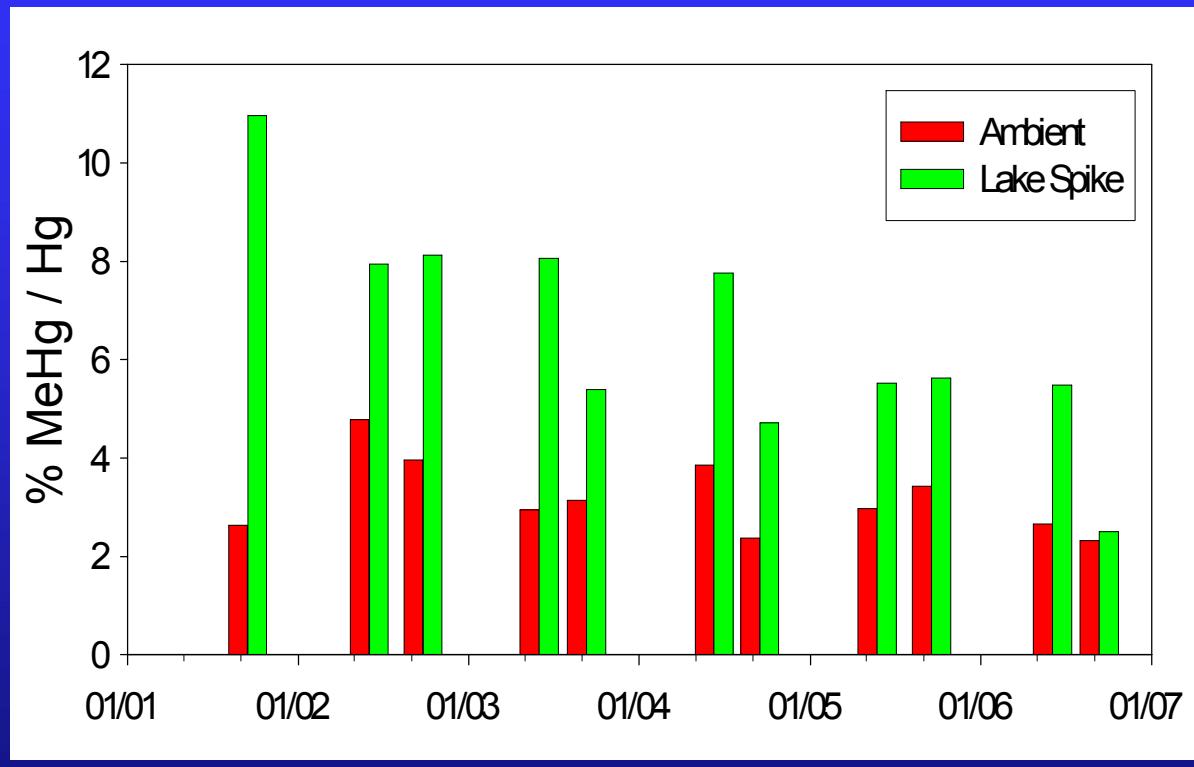
Bioavailability of sediment Hg for methylation

%MeHg/Hg

=

Net production of MeHg from inorganic Hg

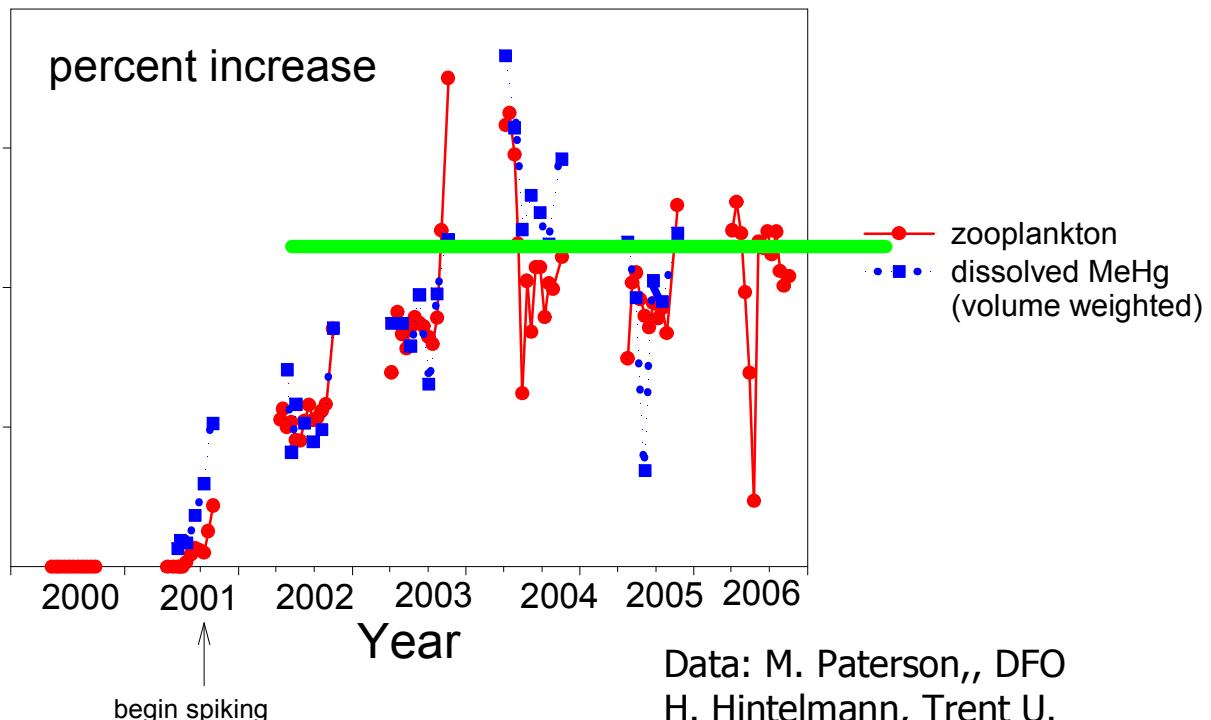
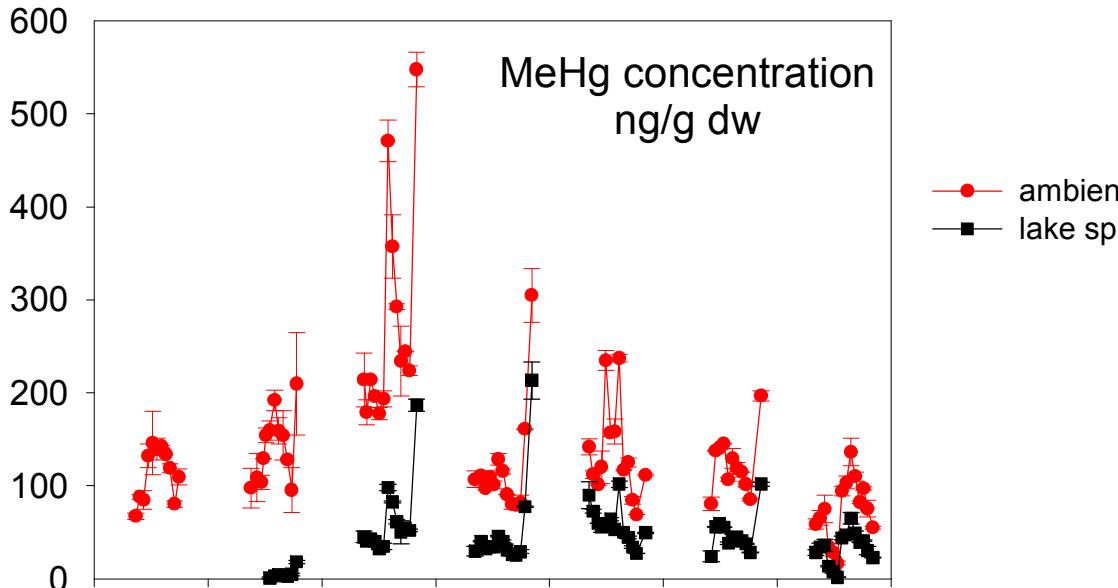
As the lake spike aged in sediments, a smaller and smaller fraction was found as MeHg.



Data: C. Gilmour, SERC

Bioavailability of lake spike Hg is now similar to ambient Hg

Zooplankton



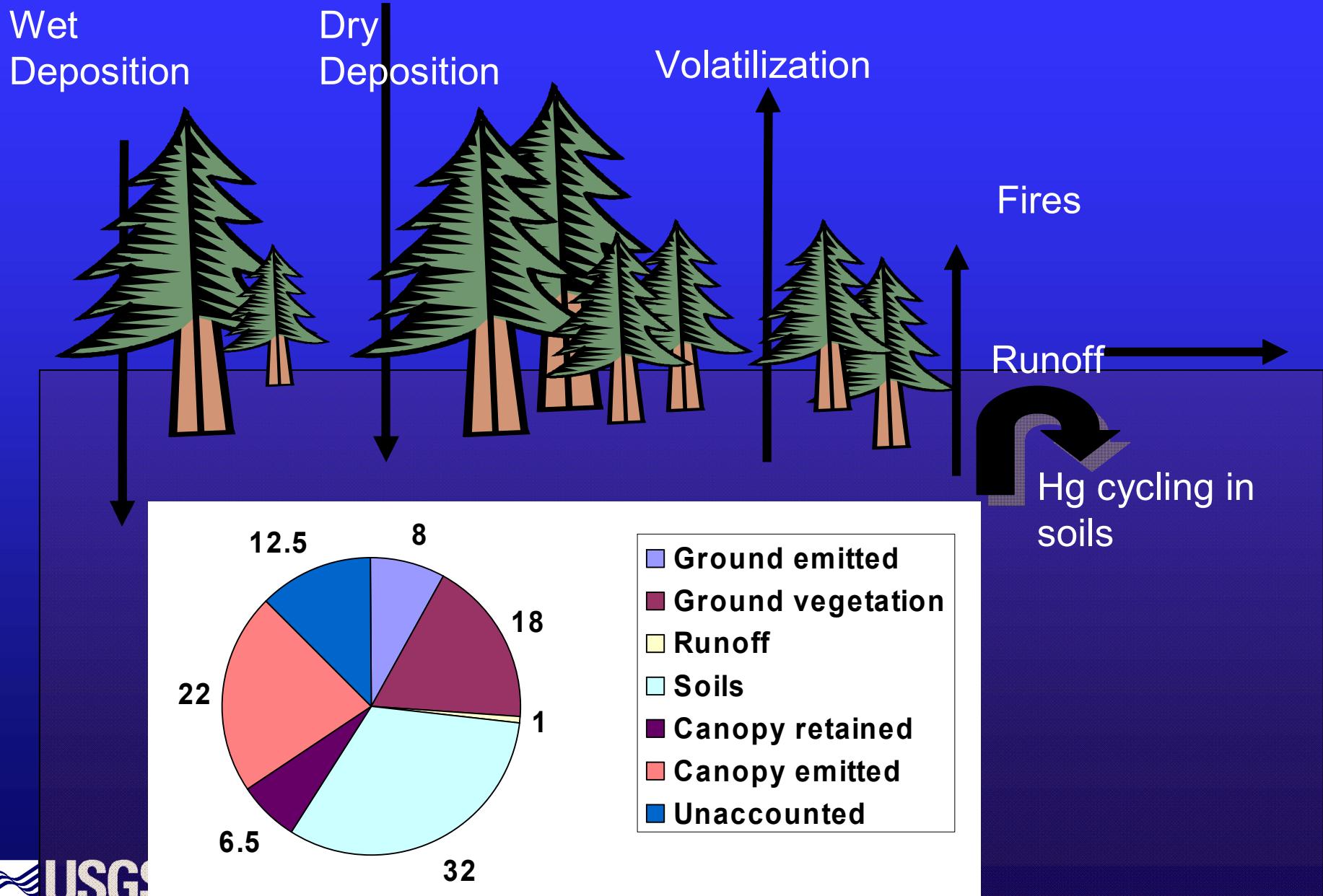
Data: M. Paterson,, DFO
H. Hintelmann, Trent U.



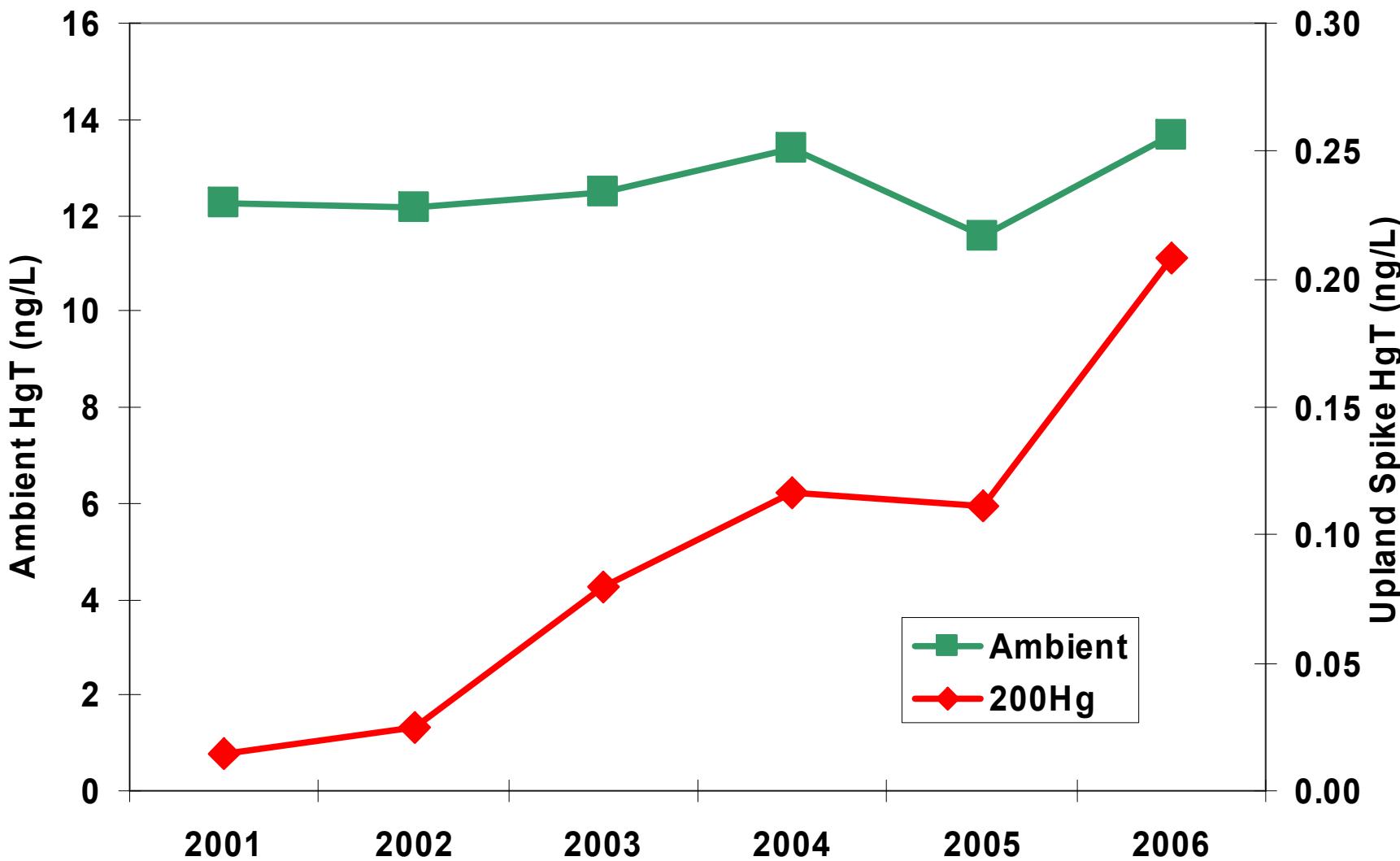
Fate of ^{200}Hg deposited to the upland



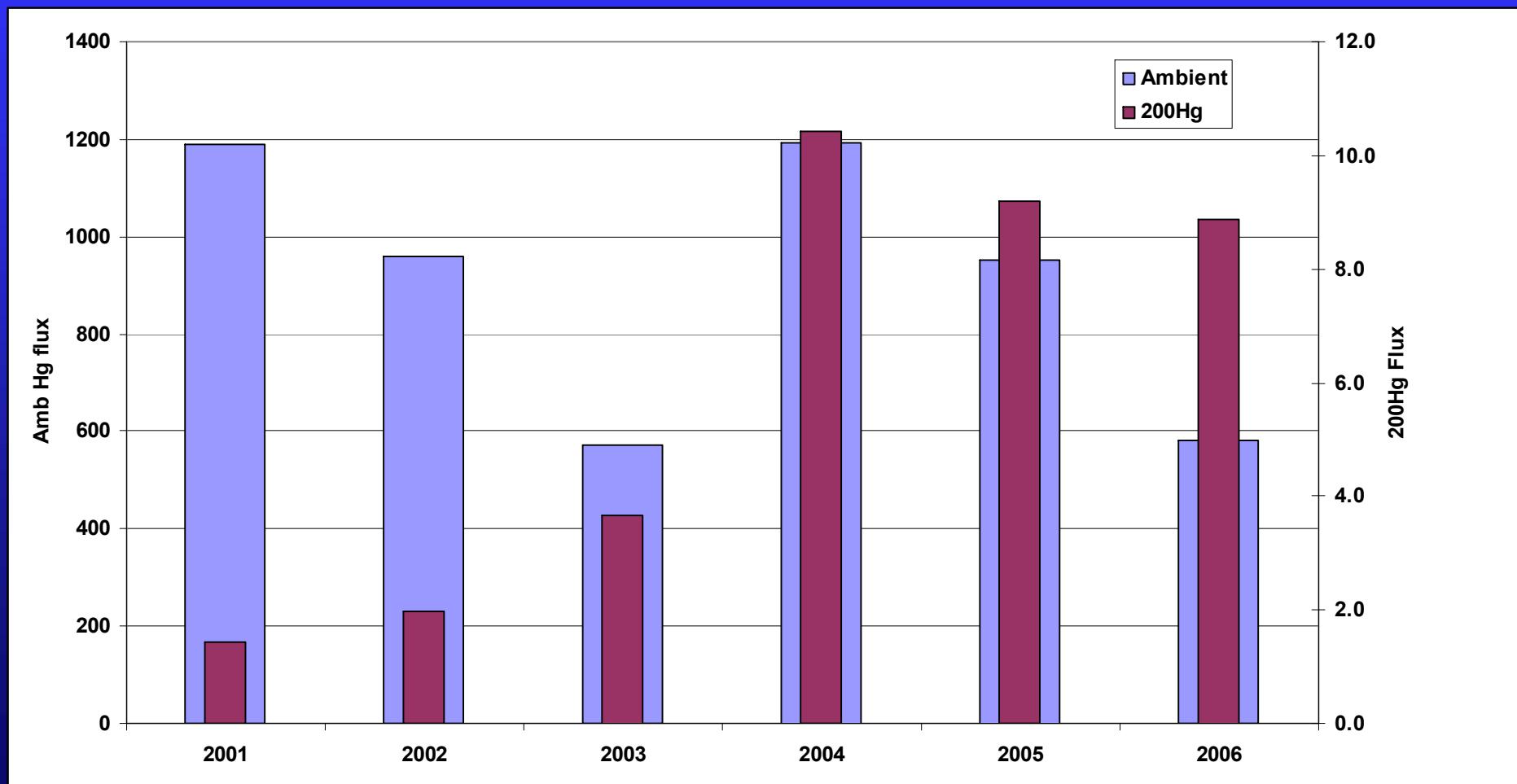
Conceptual Diagram of a Terrestrial Hg Mass-Balance Model



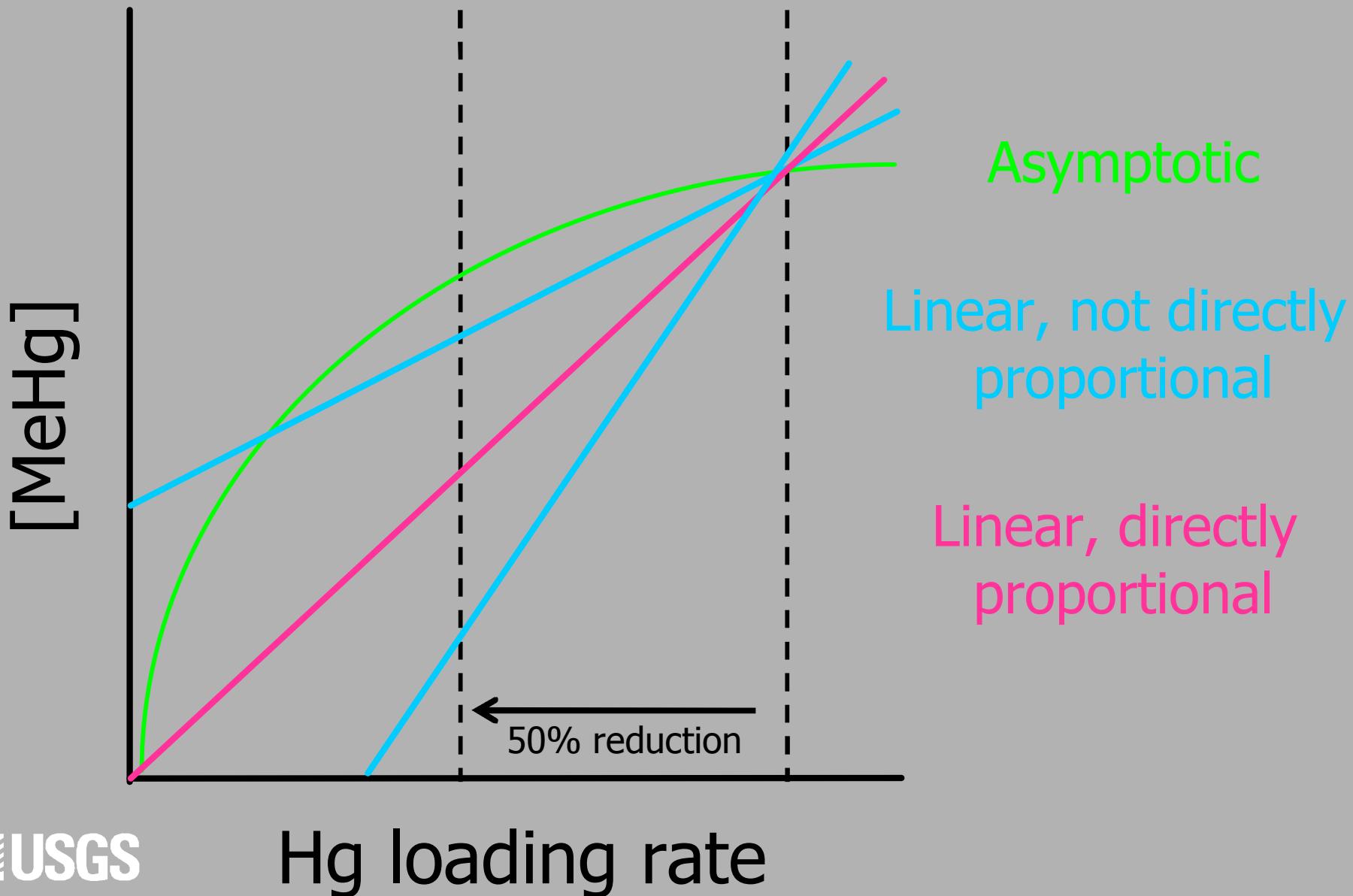
Times Series for Ambient and Upland Spike THg in Runoff from the METAALICUS Study Watershed



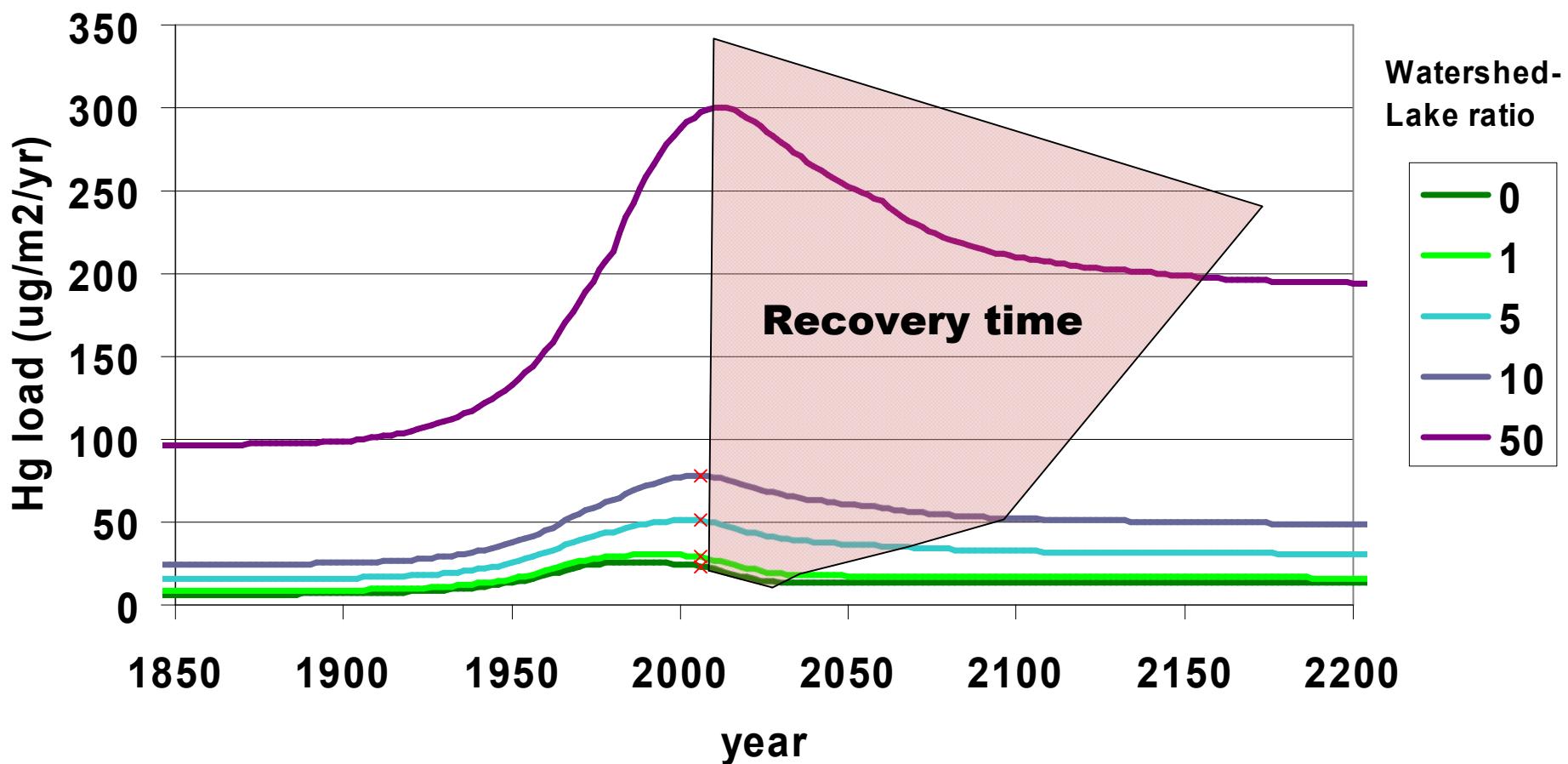
Mercury Fluxes from the Upland 2001-2006 (mg)



Understanding the Response to a Decrease is Equally (or more) Important



Recovery Time Estimates for Various Watershed-Lake Area Ratios



Summary:

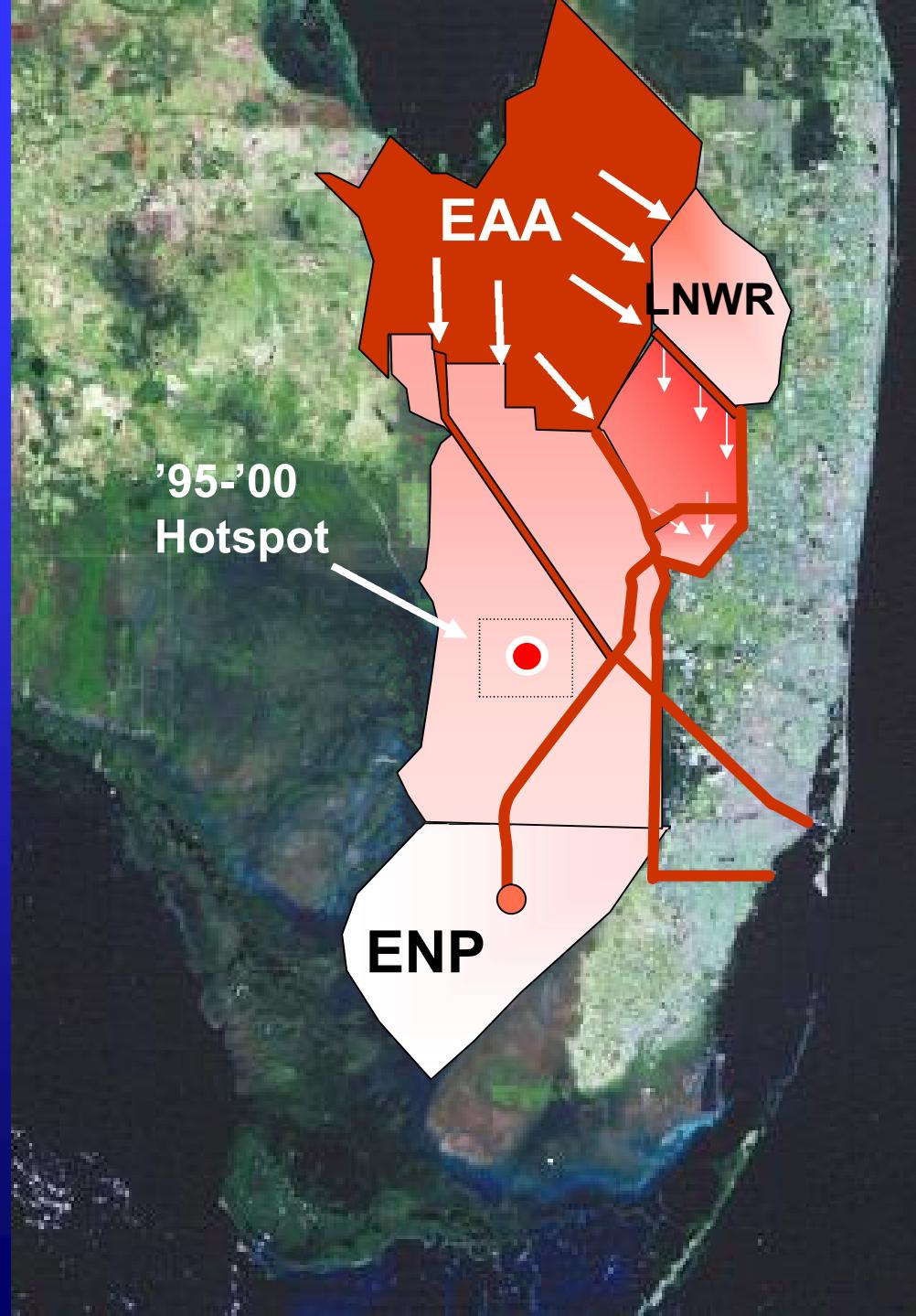
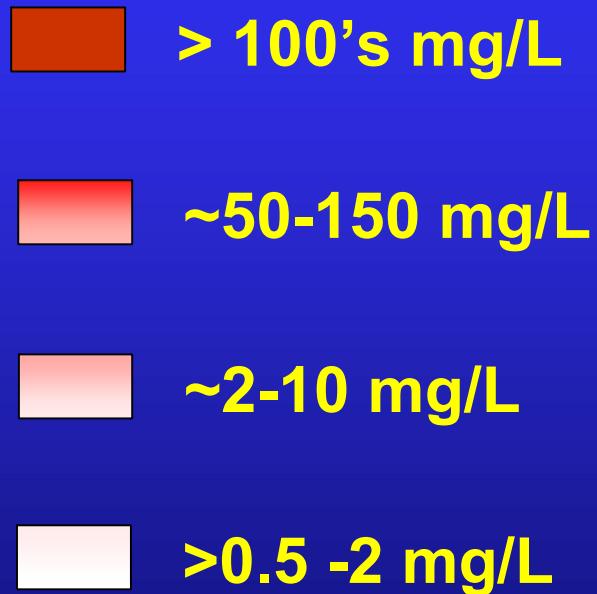
- Relative contributions of Hg from watersheds will be a principal key in determining the recovery (response) times, ranging from 10-100's of years
- Recovery will be two phase: quick response to changes in direct deposition, much longer for watershed Hg
- After seven years of loading, it appears watershed Hg in more bioavailable
- Mass accounting of Hg in the lake and the watershed lends insights into dominant accumulation points and recycling.



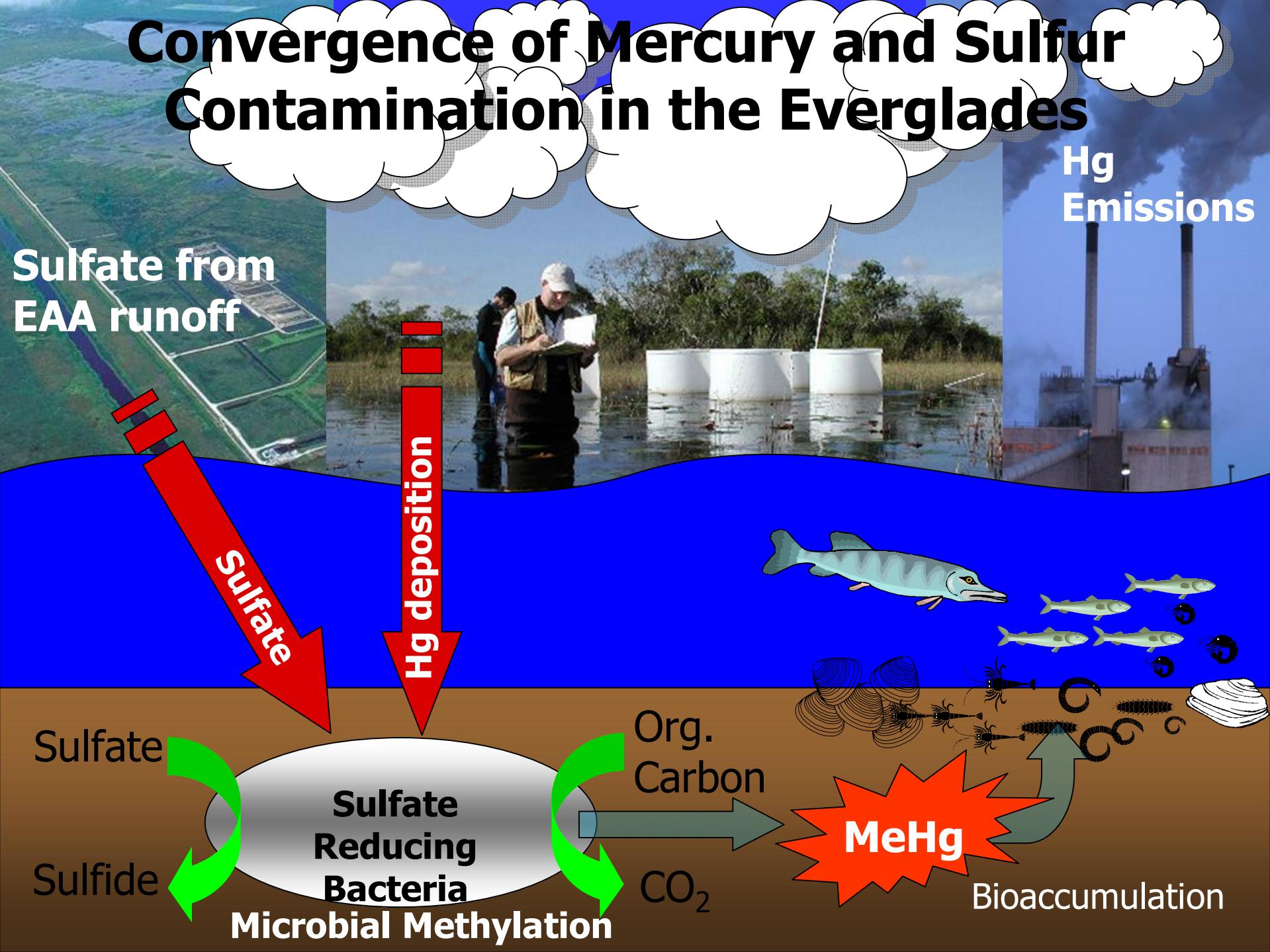
Runoff at the Lake 658 -
METAALICUS study site

The Everglades & Mercury

Extent of Sulfate Contamination in the Everglades



Convergence of Mercury and Sulfur Contamination in the Everglades



Mercury Axis of Evil



Sulfur

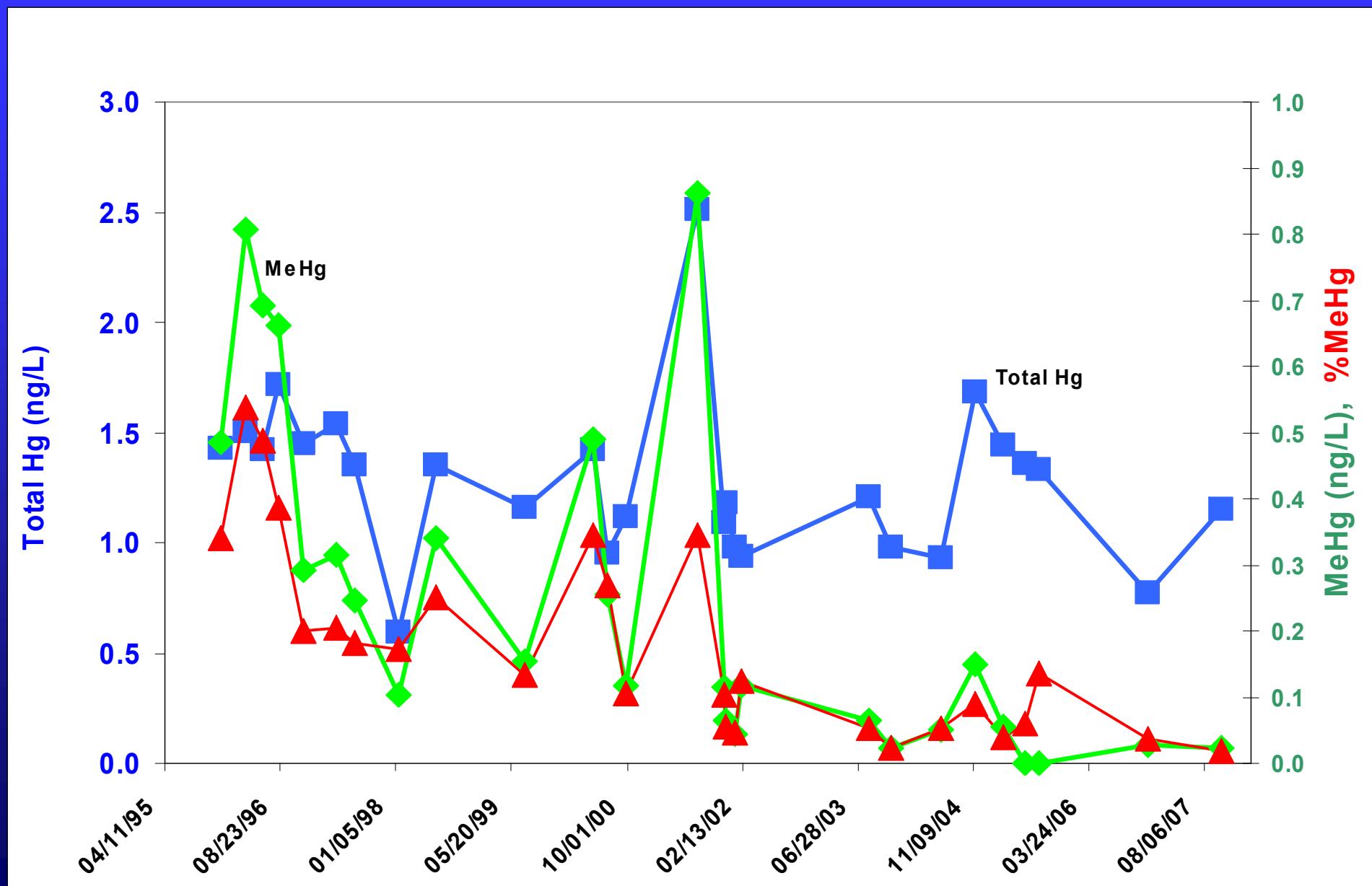


Mercury

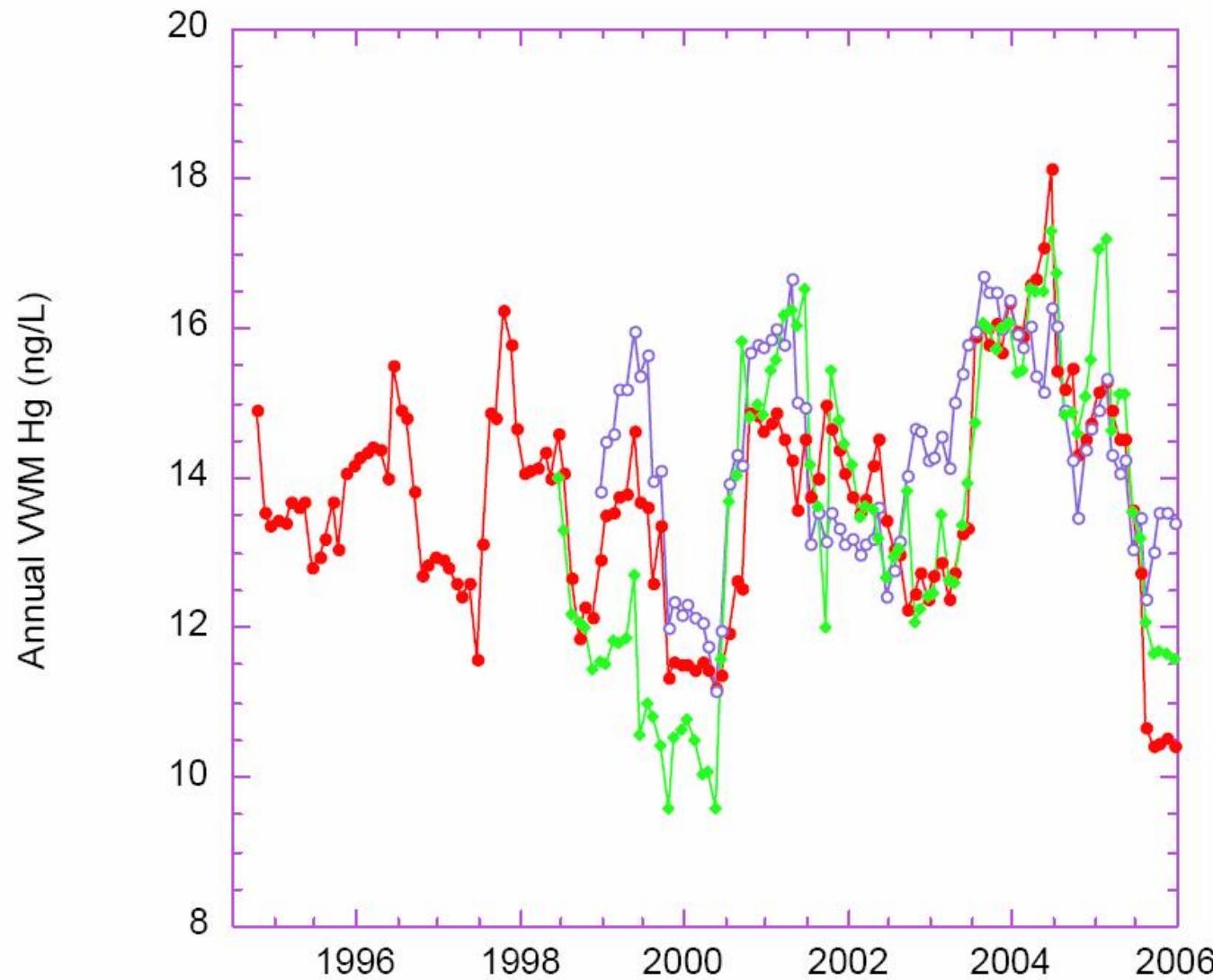


Carbon

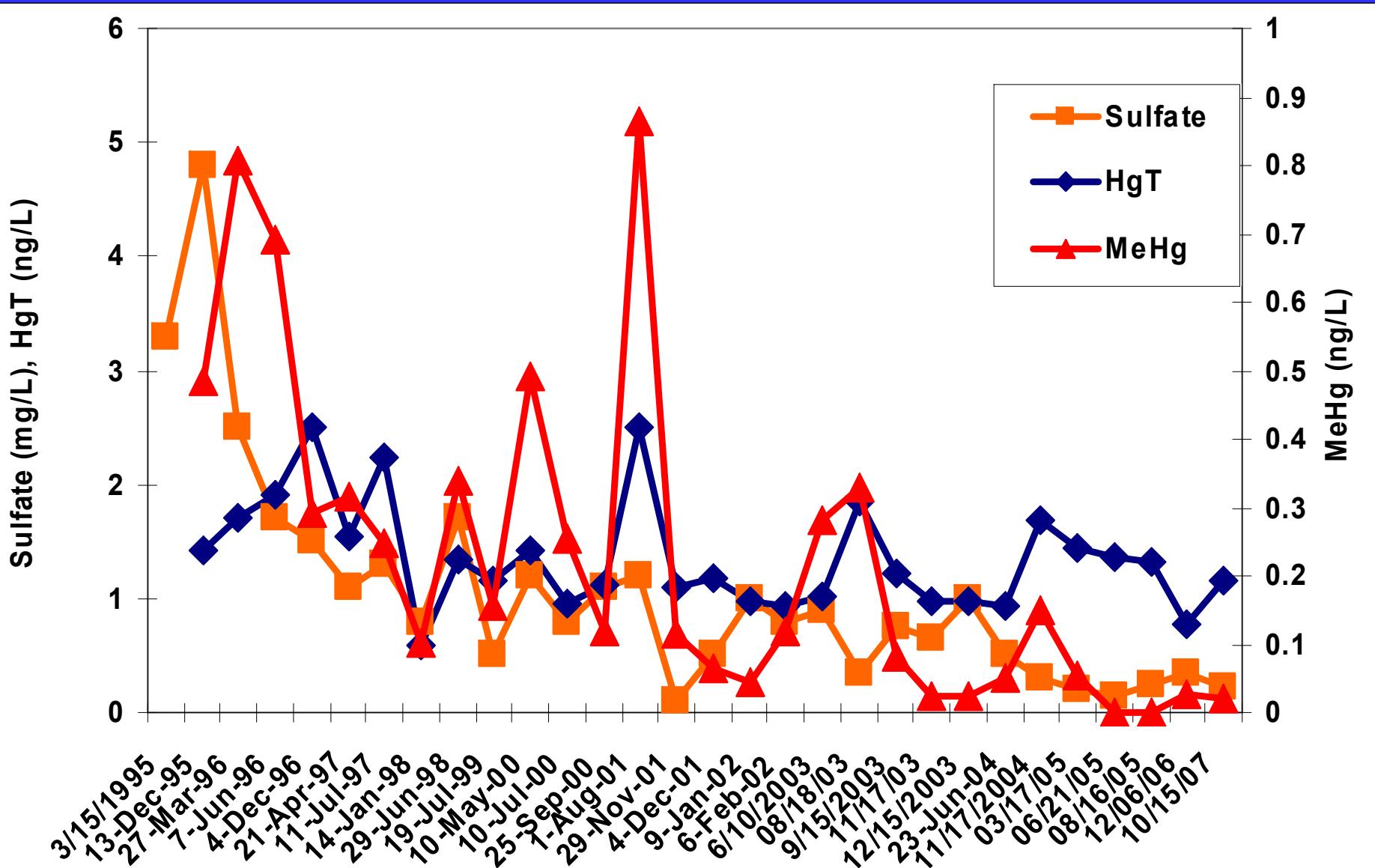
Everglades Hg & MeHg Time Series



Time Series for Mercury Deposition in South Florida 1993-06



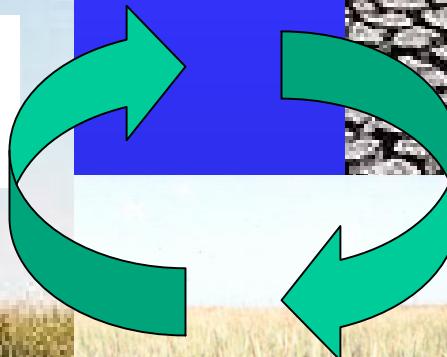
SO_4 , MeHg & HgT Time Series



But, then the Everglades dried up in 1999



Bioaccumulation &
wet cycle period

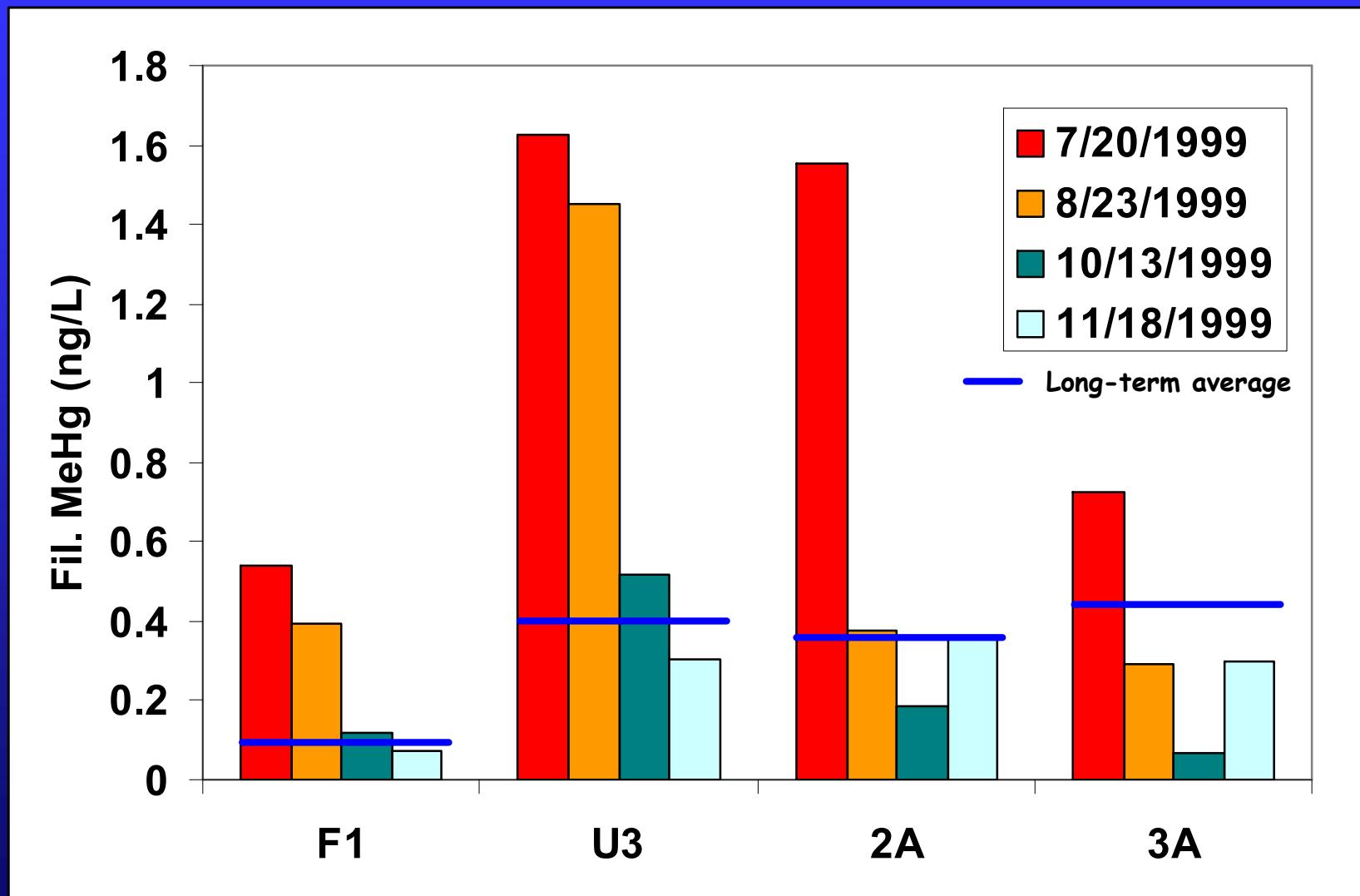


Dry down &
oxidation

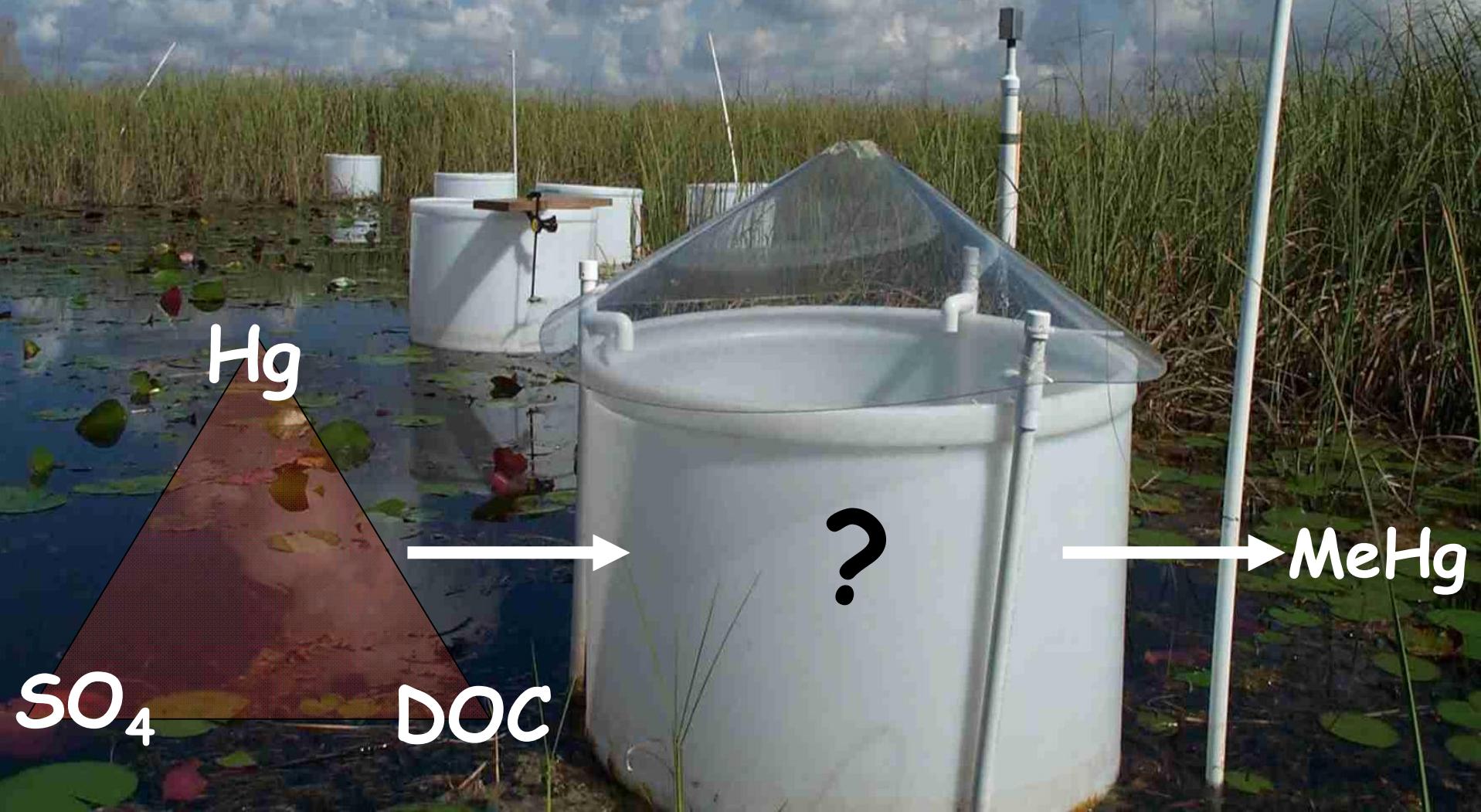
Rewetting &
methylation



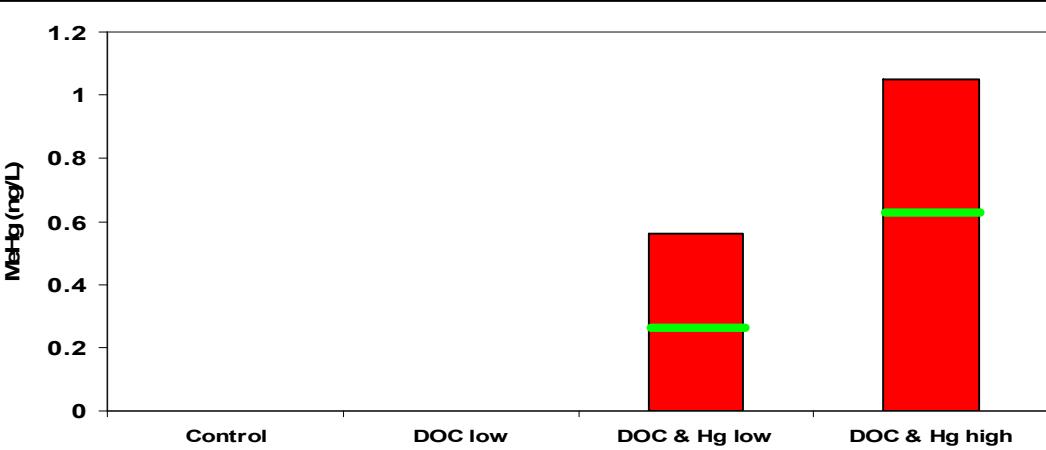
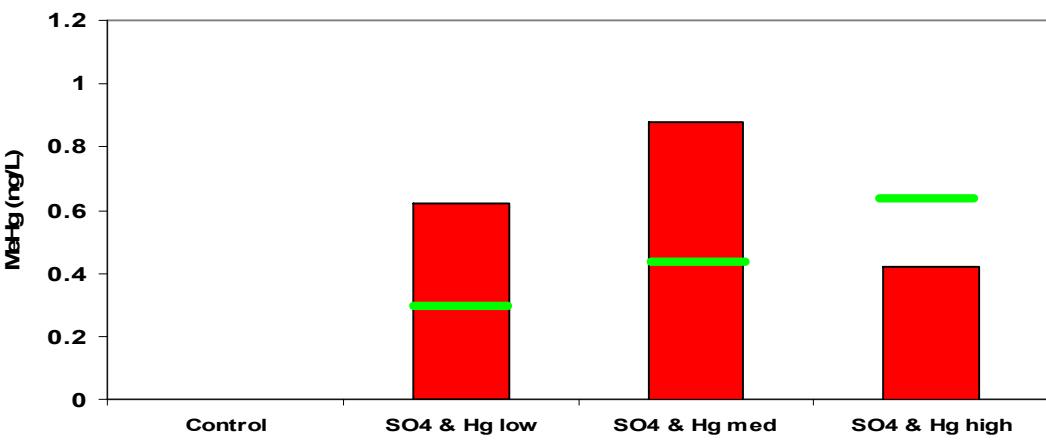
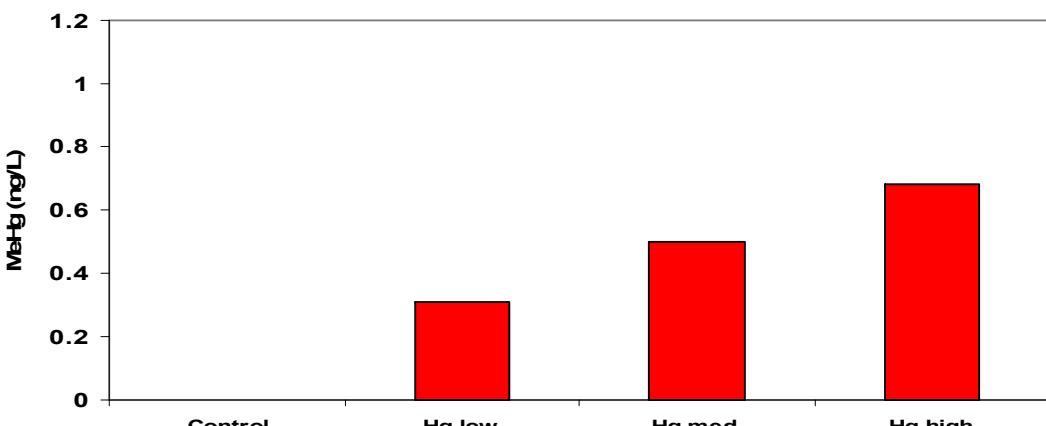
Hydro-Cycle Punctuated MeHg Production



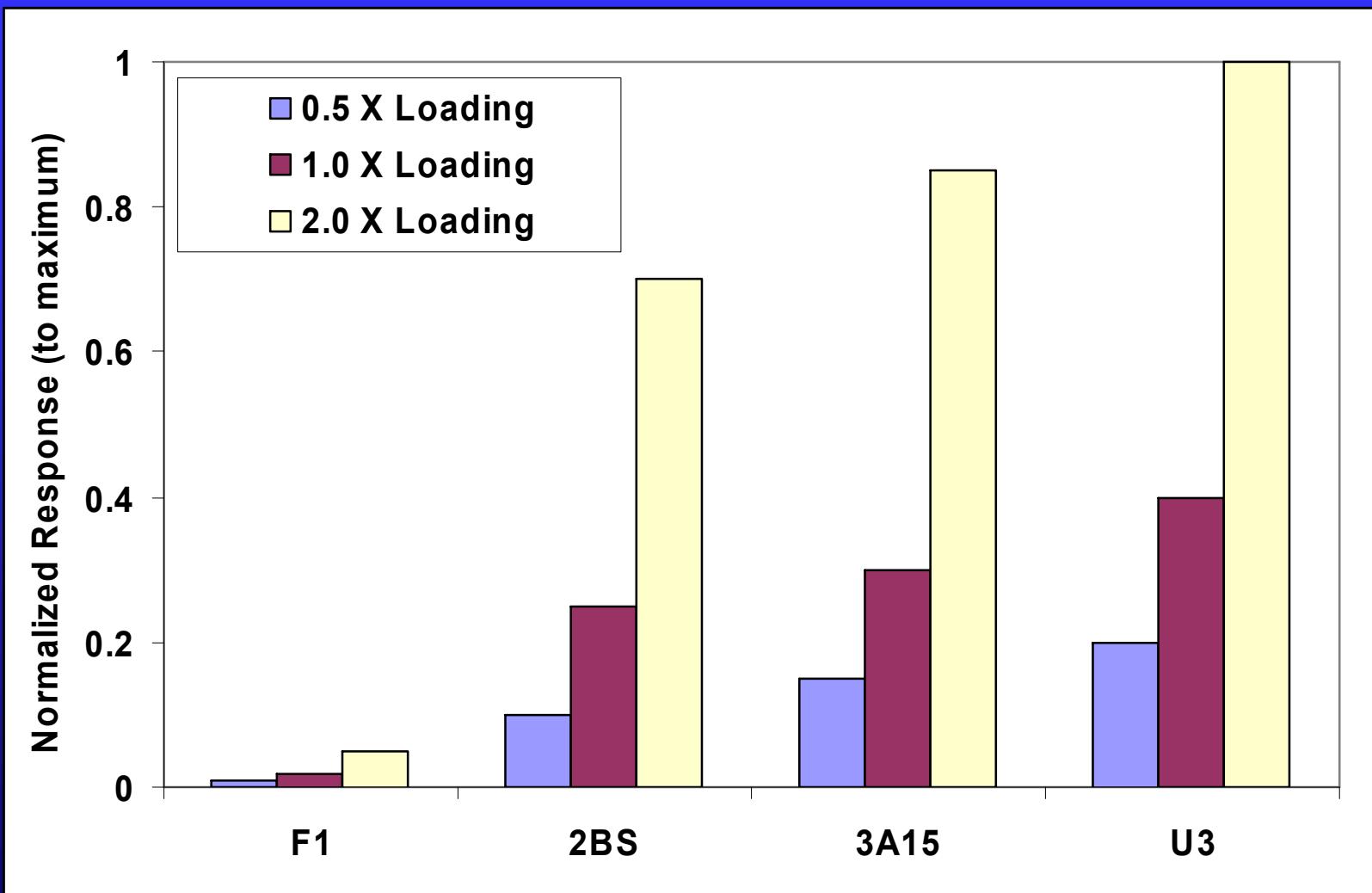
What's driving long-term MeHg levels in the Everglades?



Production of Me^{201}Hg

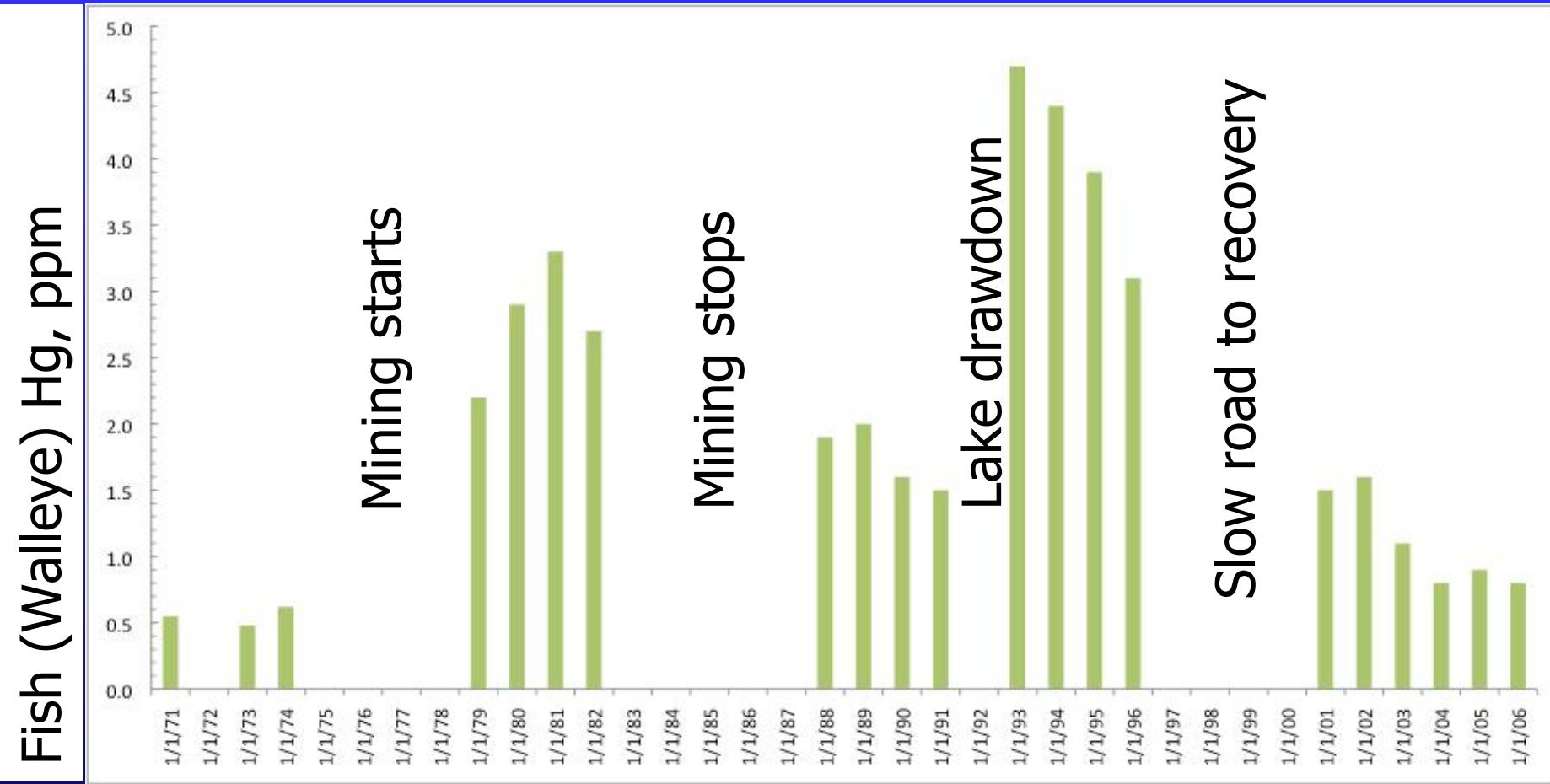


Multi-Site Dose Responses



Reservoirs and Management

Example from Deer Lake, MI



2007 USEPA National Lakes Survey:

- 909 lakes across the coterminous US
- Status of the nations lakes using indicators of indicators of trophic state, ecological health, and recreation
- Provide information on key stressors: nutrients and pathogens (and contaminants)
- Probability-based network to represent conditions of all USGS lakes across each region



2007 USEPA National Lakes Survey Sampling Sites

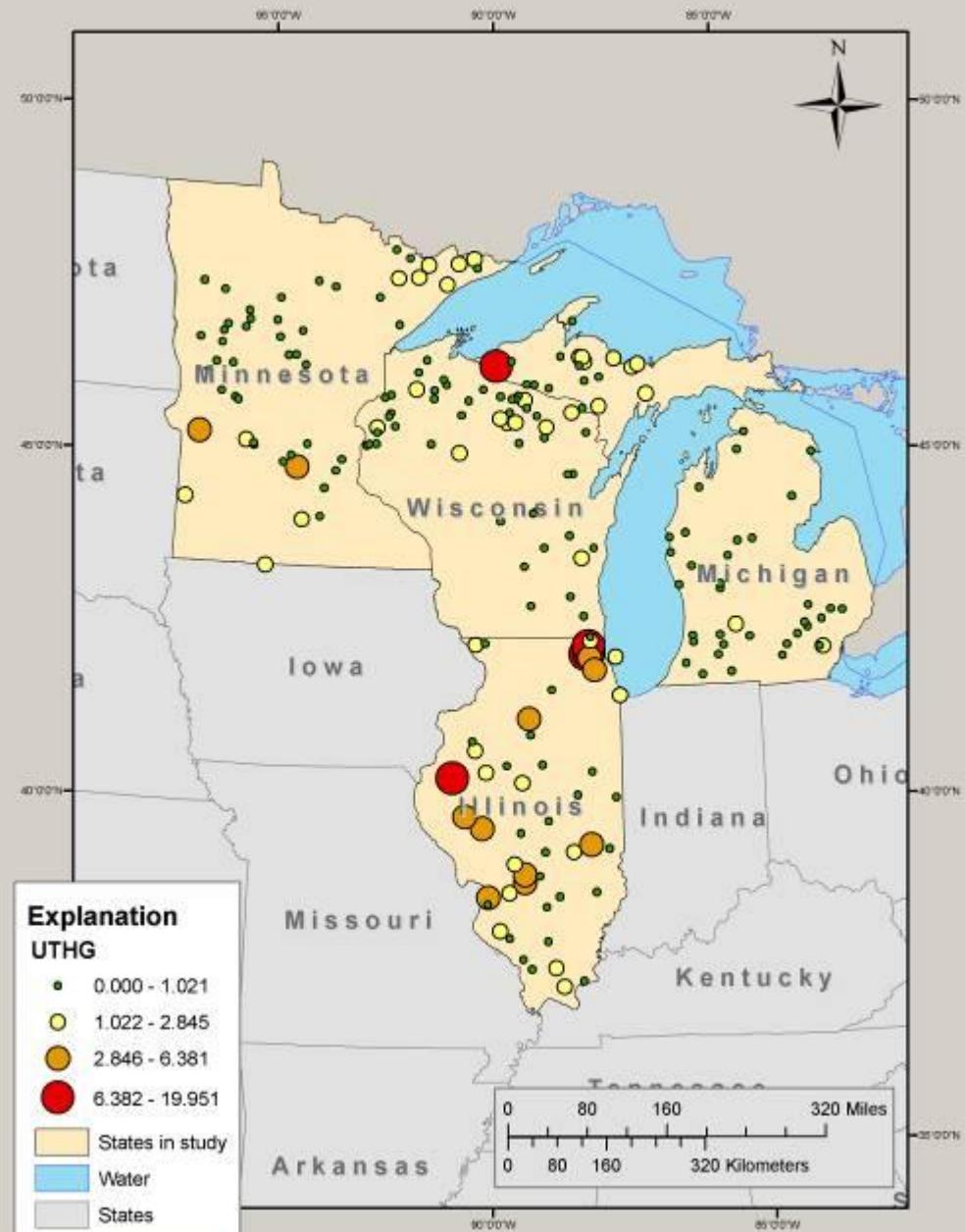
Upper Midwest Lakes Survey Sampling Sites:

- 234 Individual Sites (EPA lakes plus “enhancemets”)
- Additional 26 hypolimnion samples taken in Michigan
- Clean sampling techniques used by all sampling crews
- Sample containers, gloves, etc... provided by single source (USGS)
- Sample analysis (THg, MeHg, DOC) all conducted at a single lab



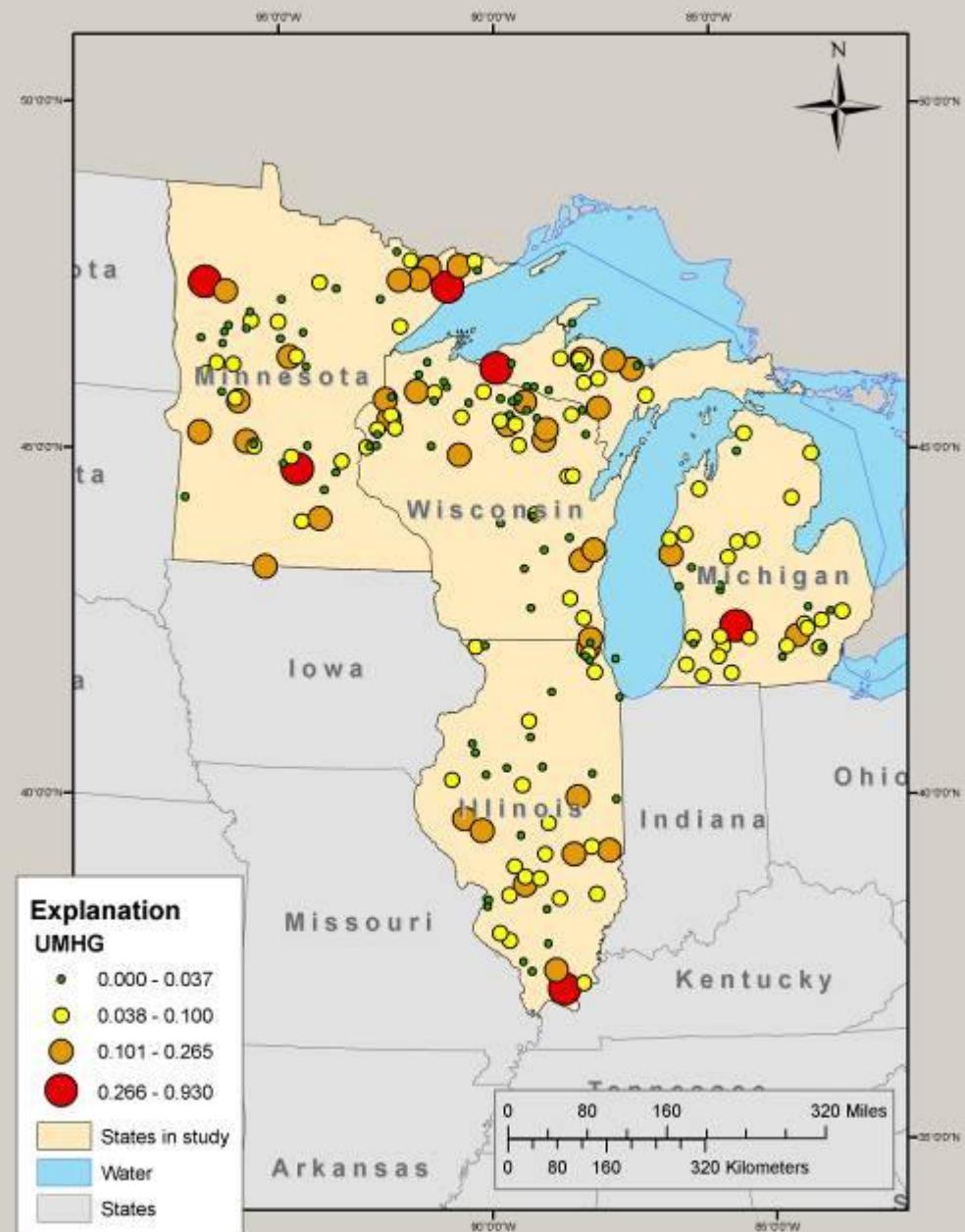
Total Hg Results:

State	THg (ng/L)	SD
Illinois	2.24	2.62
Michigan	1.13	2.49
Wisconsin	0.68	0.40
Minnesota	0.93	1.04



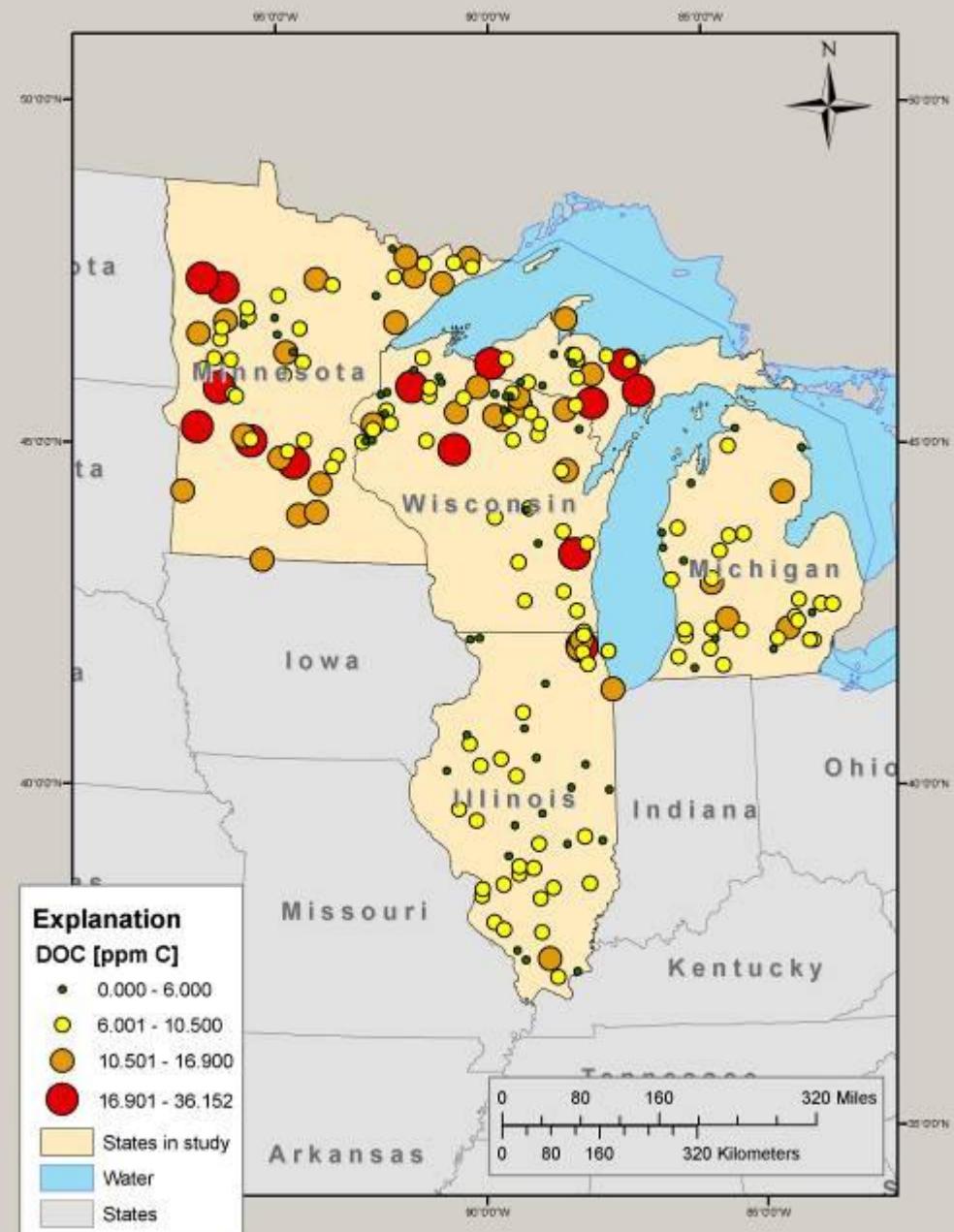
MeHg Results:

State	MeHg (ng/L)	SD
Illinois	0.07	0.08
Michigan	0.09	0.15
Wisconsin	0.06	0.06
Minnesota	0.09	0.10

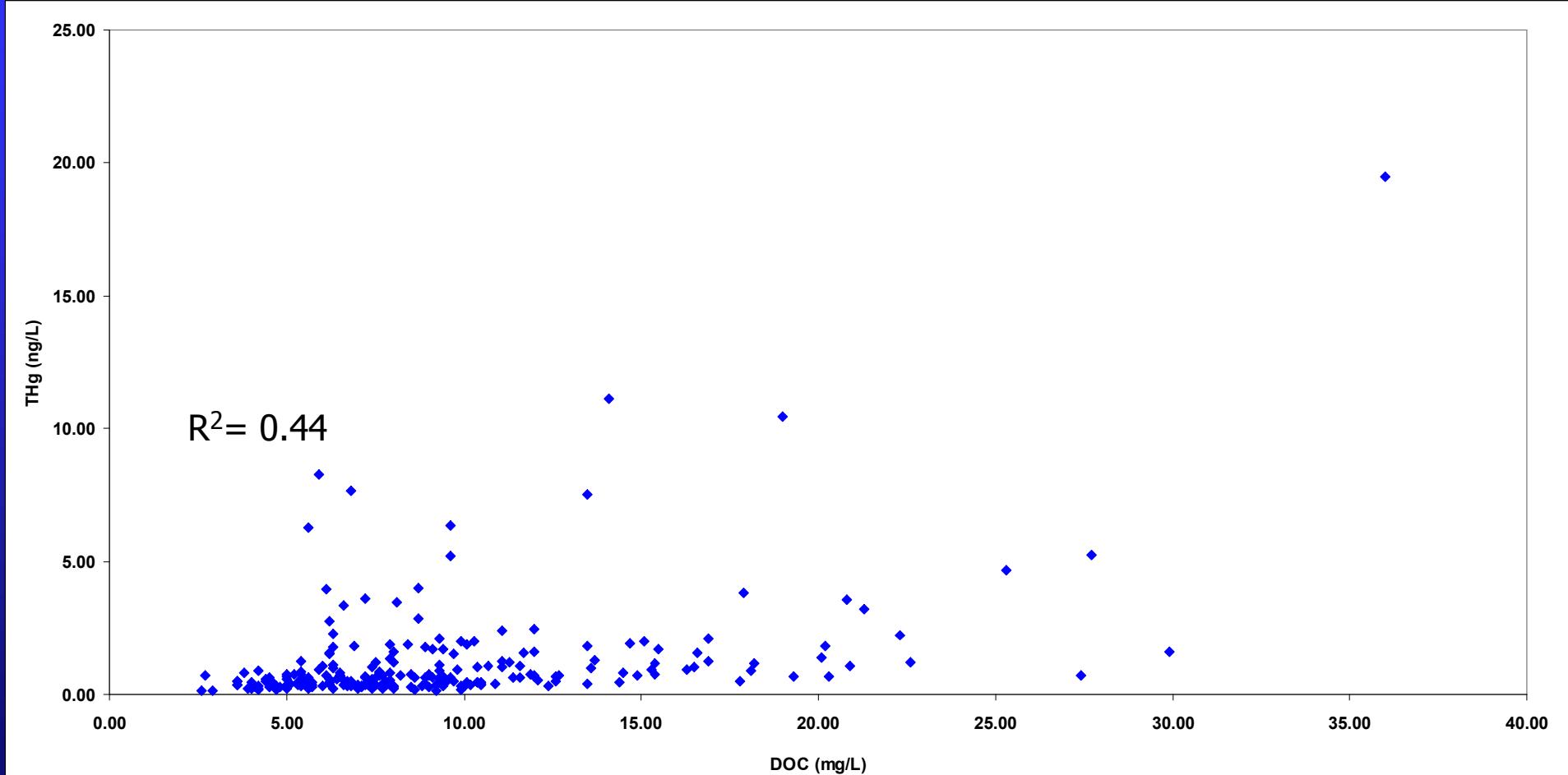


DOC Results:

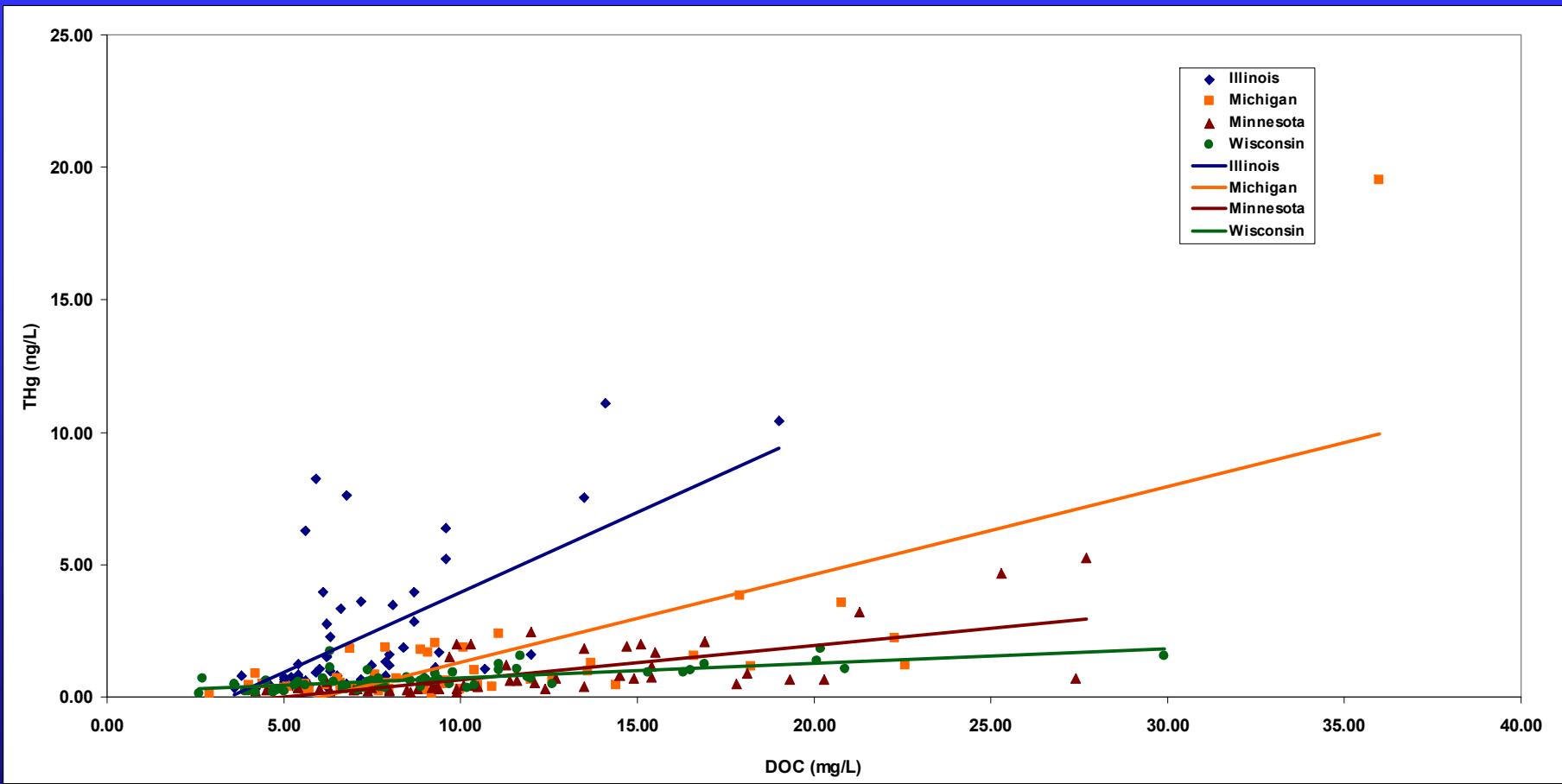
State	DOC (mg/L)	SD
Illinois	7.1	2.8
Michigan	9.5	5.6
Wisconsin	9.5	5.1
Minnesota	12.1	5.4



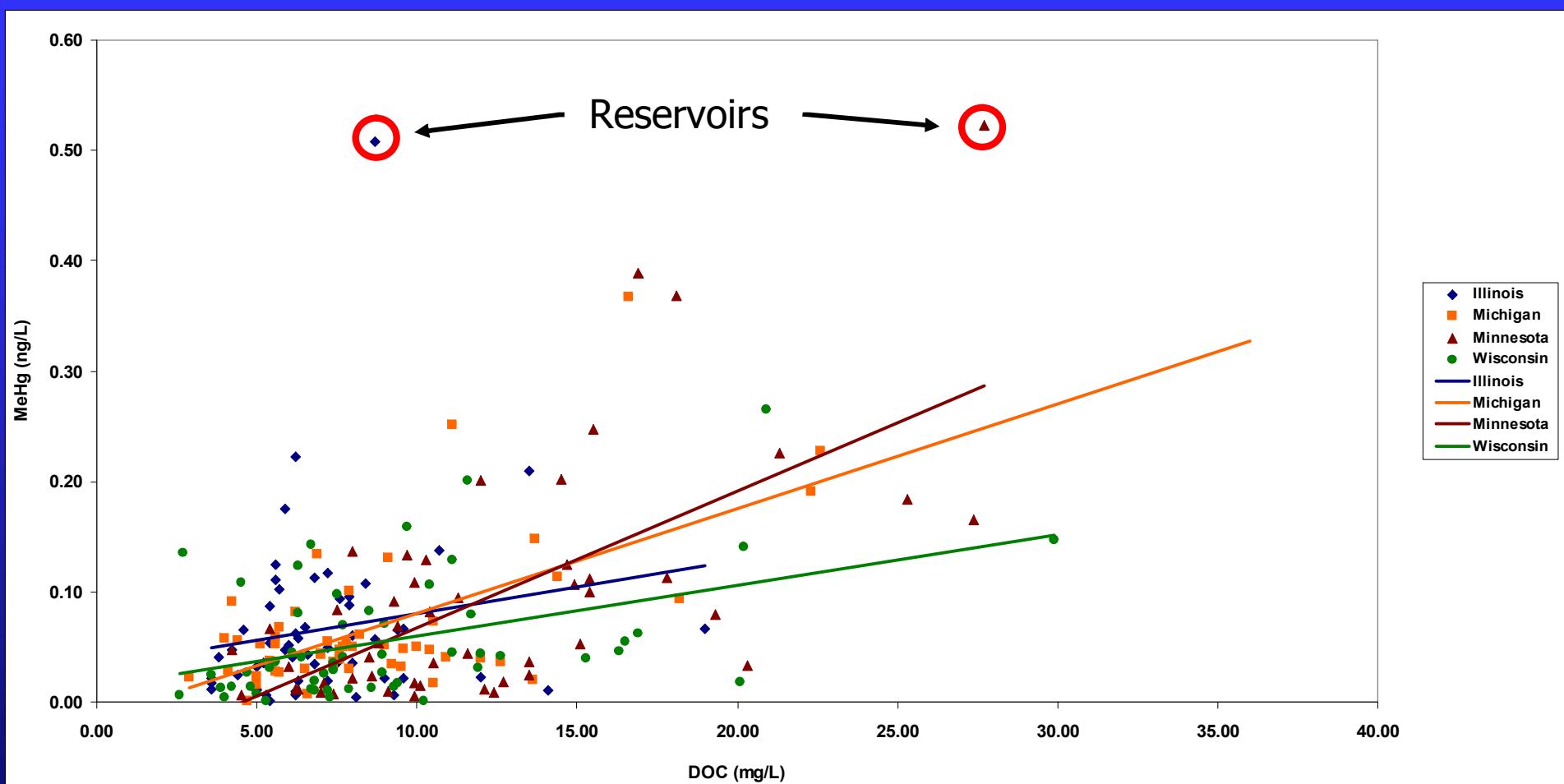
Is DOC Really a Strong Driver?



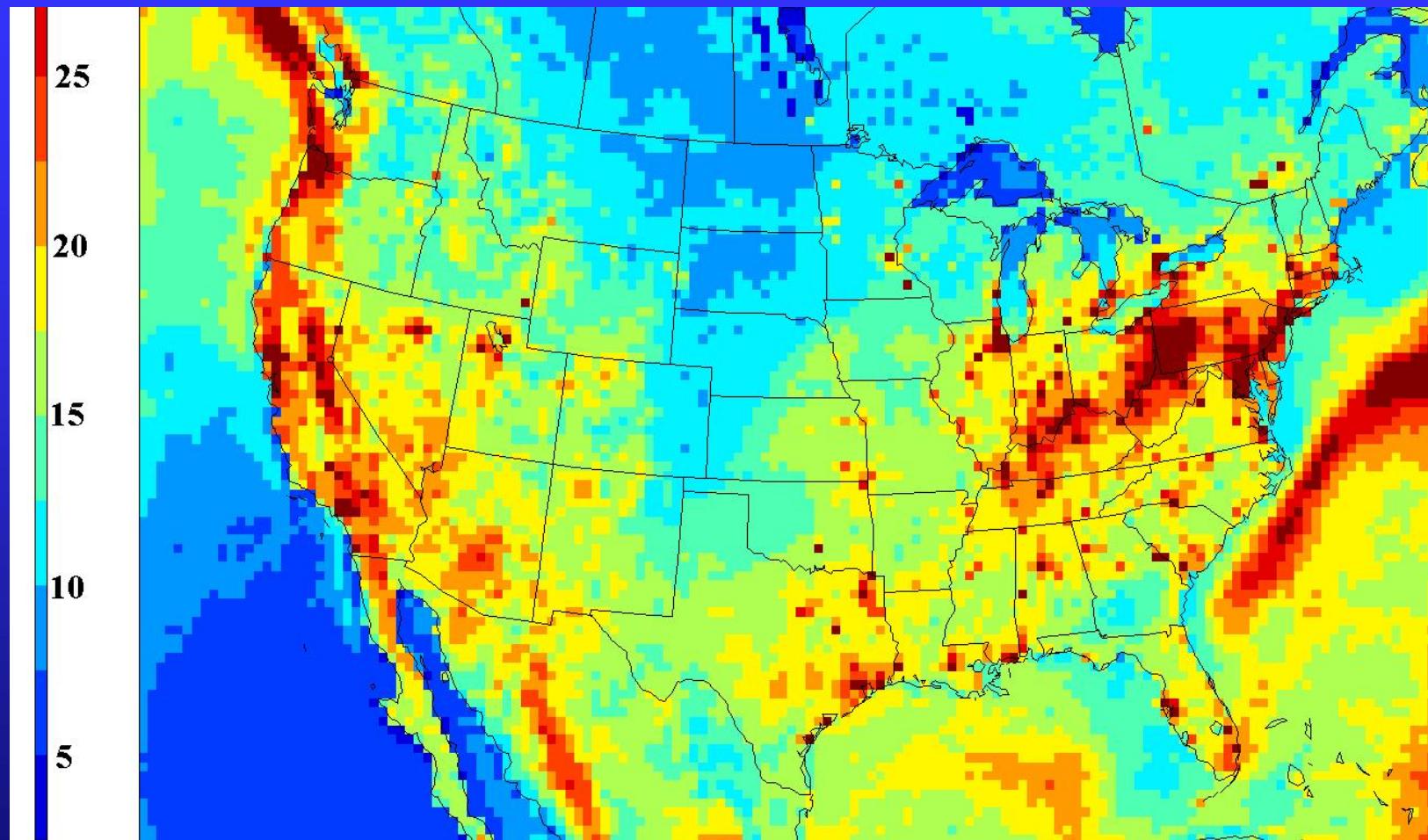
Yes, the answer is in the details!



Does water body type matter?



Corroborating Evidence from CMAQ Modeling



CMAQ-Simulated (2001) Total Hg Deposition
(in micrograms per square meter)

Implications for Air, Water and Land Management

- Reducing Hg loading (by water ever means) will reduce exposure.
- However, this is only one means to reduce MeHg production in aquatic ecosystems.
- Landscape management actions can decrease or *substantially increase* methylation of inorganic Hg(II), influencing exposure of biota to MeHg.
 - Reservoir construction (water-level fluctuation, carbon additions, flushing rate, temperature, ...)
 - Disturbances (dredging, fire, logging, hurricanes, chemical amendments)
 - Food-web alterations (exotics...)